

digital

WORLD-WIDE SALES AND SERVICE

MAIN OFFICE AND PLANT

DIGITAL EQUIPMENT CORPORATION
146 Main Street, Maynard, Massachusetts 01754
Telephone: From Metropolitan Boston: 646-8600
Elsewhere: (617)-897-5111
TWX: 710-347-0212 Cable: Digital Mayn. Telex: 94-9457

DOMESTIC

NORTHEAST

NORTHEAST OFFICE:
146 Main Street, Maynard, Massachusetts 01754
Telephone: (617)-646-8600 TWX: 710-347-0212

BOSTON OFFICE:
890 Main Street, Cambridge, Massachusetts 02139
Telephone: (617)-491-6130 TWX: 710-320-1167

ROCHESTER OFFICE:
480 Clinton Avenue So., Rochester, New York 14620
Telephone: (716)-454-2000 TWX: 510-253-3078

NEW HAVEN OFFICE:
129 College Street, New Haven, Connecticut 06510
Telephone: (203)-777-5797 TWX: 710-465-0692

MID-ATLANTIC

NEW YORK OFFICE:
Suite #1
71 Grand Avenue, Palisades Park, New Jersey 07650
Telephone: (201)-941-2016 or (212)-594-6955 TWX: 710-992-8974

PARSIPPANY OFFICE:
1259 Route 46, Parsippany, New Jersey 07054
Telephone: (201)-335-3300 or (212)-279-4735 TWX: 710-987-8319

PRINCETON OFFICE:
3 Ninianne Boulevard, Princeton, New Jersey 08540
Telephone: (609)-452-2940 TWX: 510-685-2337

LONG ISLAND:
1919 Middle Country Road, Centereach, L.I., New York 11720
Telephone: (516)-385-5410 TWX: 510-228-6505

PHILADELPHIA OFFICE:
1100 West Valley Road, Wayne, Pennsylvania 19087
Telephone: (215)-687-1405 TWX: 510-688-4461

WASHINGTON OFFICE:
Executive Building
7100 Baltimore Ave., College Park, Maryland 20740
Telephone: (301)-779-1100 TWX: 710-826-9662

SOUTHEAST

HUNTSVILLE OFFICE:
Suite #1 - Holiday Office Center
3322 Memorial Parkway S.W., Huntsville, Ala 35801
Telephone: (205)-881-7730 TWX: 810-726-2122

COCOA OFFICE:
412 High Point Drive, Cocoa, Florida 32922
Telephone: (305)-632-9283 TWX: 510-957-1448

INTERNATIONAL

CANADA

Digital Equipment of Canada, Ltd.
150 Rosamond Street, Carleton Place, Ontario, Canada
Telephone: (613)-257-2615 TWX: 610-961-1651

Digital Equipment of Canada, Ltd.
230 Lakeshore Road East, Port Credit, Ontario, Canada
Telephone: (416)-279-6111 TWX: 610-492-4306

Digital Equipment of Canada, Ltd.
640 Cathcart Street, Suite 205, Montreal, Quebec, Canada
Telephone: (514)-961-6394 TWX: 610-421-3960

Digital Equipment of Canada, Ltd.
5331-103 Street
Edmonton, Alberta, Canada
Telephone: (403)-434-9333 TWX: 610-831-2248

GERMANY

Digital Equipment GmbH
5 Koeln, Neue Weyerstr. 10, West Germany
Telephone: 23 55 01 Telex: 841-888-2269
Telegram: Flip Chip Koeln

Digital Equipment GmbH
8 Muenchen, 2 Theresienstr. 29, West Germany
Telephone: 26 30 53 Telex: 841-24226

ENGLAND

Digital Equipment Co. Ltd.
Arkwright Road, Reading, Berkshire, England
Telephone: Reading 85131 Telex: 851-84327

Digital Equipment Co. Ltd.
13/15 Upper Precinct
Bolton Road, Walkden, Worsley, Manchester, M285AZ England
Telephone: (061) 790 4591

CENTRAL

PITTSBURGH OFFICE:
400 Penn Center Boulevard, Pittsburgh, Pennsylvania 15235
Telephone: (412)-243-8500 TWX: 710-797-3657

CHICAGO OFFICE:
69 North Broadway, Des Plaines, Illinois 60018
Telephone: 312-292-0144 TWX: 910-233-0894

ANN ARBOR OFFICE:
3853 Research Park Drive, Ann Arbor, Michigan 48104
Telephone: (313)-761-1150 TWX: 810-223-6053

MINNEAPOLIS OFFICE:
Digital Equipment Corporation
15016 Minnetonka Industrial Road
Minnetonka, Minnesota 55343
Telephone: 612-935-1744 TWX: 910-576-2818

CLEVELAND OFFICE:
Park Hill Bldg., 35104 Euclid Ave., Willoughby, Ohio 44094
Telephone: (216)-946-8484

DAYTON OFFICE:
3110 South Kettering Blvd., Dayton, Ohio 45439
Telephone: (513)-299-7377 TWX: 810-459-1676

HOUSTON OFFICE:
3417 Milam Street, Suite A, Houston, Texas 77002
Telephone: (713)-523-2529 TWX: 910-881-1651

WEST

LOS ANGELES OFFICE:
801 E. Ball Road, Anaheim, California 92805
Telephone: (714)-776-6932 or (213)-625-7669 TWX: 910-591-1189

SAN FRANCISCO OFFICE:
560 San Antonio Road, Palo Alto, California 94306
Telephone: (415)-326-5640 TWX: 810-373-1266

SEATTLE OFFICE:
McAusland Building, 10210 N.E. 8th Street
Bellevue, Washington 98004
Telephone: (206)-454-4039 TWX: 910-443-2306

ALBUQUERQUE OFFICE:
6303 Indian School Road, N.E., Albuquerque, N.M. 87110
Telephone: (505)-296-5411 TWX: 910-989-0614

DENVER OFFICE:
2305 South Colorado Blvd., Suite #5, Denver, Colorado 80222
Telephone: 303-757-3332 TWX: 910-931-2650

SALT LAKE CITY OFFICE:
431 South 3rd East, Salt Lake City, Utah 84111
Telephone: 801-328-9838

FRANCE

Equipement Digital
22, rue du Champ de l'Alouette, Paris 13^e, France
Telephone: 336-0384 Telex: 842-26705

NETHERLANDS

Digital Equipment N.V.
Koninginnegracht 65, The Hague, Netherlands
Telephone: 635961 Telex: 32533

SWEDEN

Digital Equipment Aktiebolag
Vretenvagen 2, Solna 1, Stockholm, Sweden
Telephone: 96 13 90
Telex: Digital Stockholm 17050
Cable: Digital Stockholm

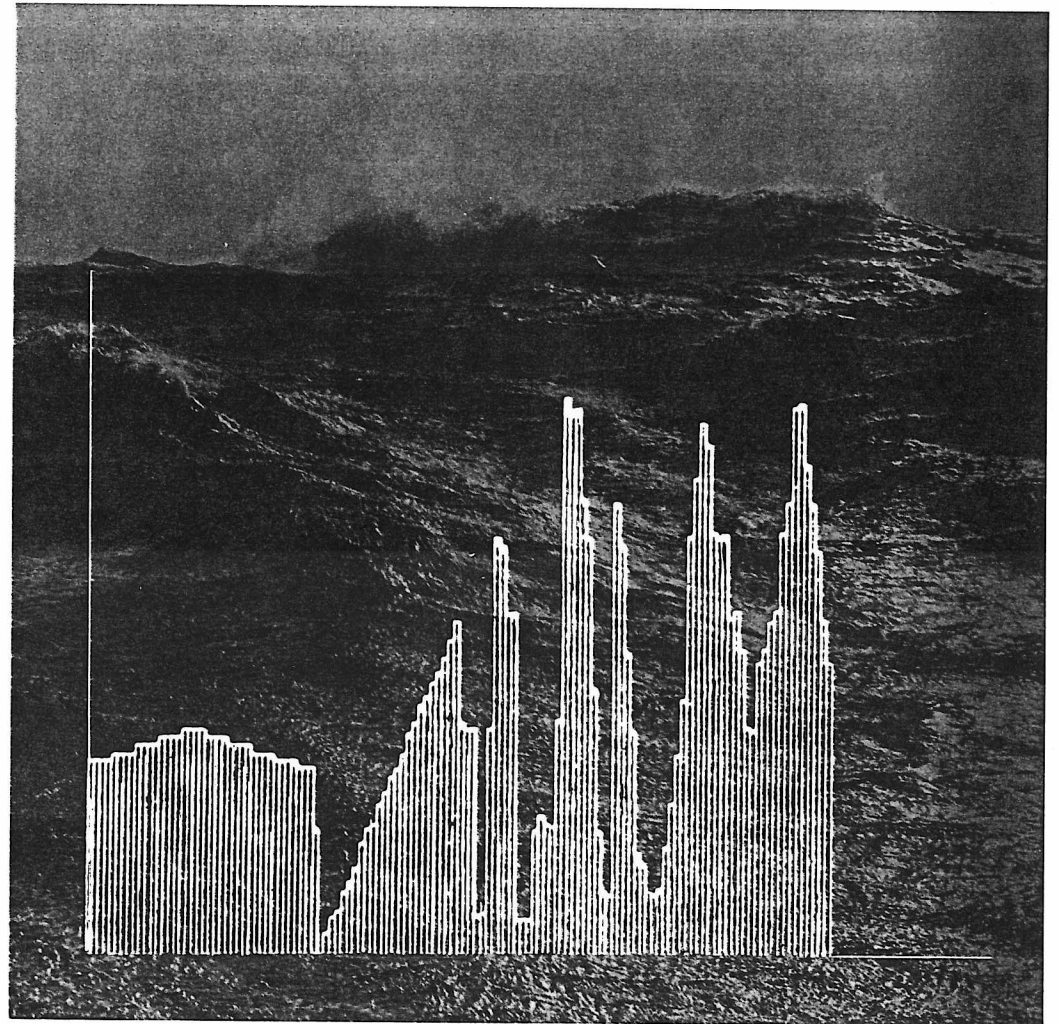
AUSTRALIA

Digital Equipment Australia Pty. Ltd.
75 Alexander Street, Crows Nest, N.S.W. 2065, Australia.
Telephone: 439-2566 Telex: AA20740
Cable: Digital, Sydney
Digital Equipment Australia Pty. Ltd.
60 Park Street, South Melbourne, Victoria, 3205
Telephone: 26 6542 Telex: AA30700

JAPAN

Rikel Trading Co., Ltd. (sales only)
Kozato-Kaikan Bldg.
No. 18-14, Nishishimbashi 1-chome
Minto-ku, Tokyo, Japan
Telephone: 5913246 Telex: 7814208
Digital Equipment Corporation (service only)
Fukuyoshicho Building, No. 2-6, Roppongi 2-Chome,
Minato-Ky, Tokyo
Telephone No. 582-4952 Telex No. 0242-2650

COMPUTERS IN OCEANOGRAPHY



DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

That the general purpose computer can be an effective tool in dealing with the data gathered on oceanographic surveys is no new story. Nor is the power of the computer for use as a navigation aid. What is new, is that more and more oceanographers are learning to use computers on-board — as personal research instruments. Researchers are able to sample, collate, store, reduce, display, compute, and permanently record data as they are collected. They are able to do this without tedious and often inadequate hand calculations. They are able to plan and execute more ambitious research activities. They are able to use the power of an onboard general purpose computer to aid in navigation via satellite and connect their computer directly to modern in-situ measurement devices.

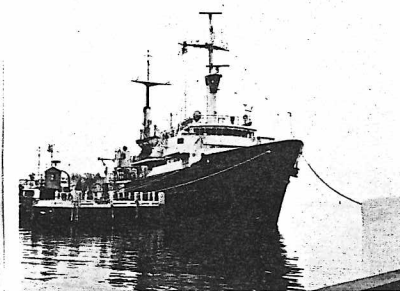
An on-board computer means that data can be monitored and analyzed in time for creative variations in experimental technique. Sampling sequences can be modified. Instrument failure can be detected on the spot; stations can be recast. The oceanographer learns, through the installation of his own general purpose computer a new scientific discipline that will be of continuing use throughout his research career. DEC computers include, as part of the basic price, one of the best software packages available, including FORTRAN. Customers are trained in DEC programming and maintenance courses.

Digital Equipment Corporation has played a pioneering role in making available on-board computers for oceanography. The low cost (\$18,000) of the PDP-8 made available a fast, full-capability 1.5 μ sec core memory scientific computer to many researchers who could not previously afford their own computer. DĀTAK, a special language, has been developed to make on-line, oceanographic data gathering and analysis easy for the oceanographer. Oceanographic programs and routines are available for immediate on-board use.

The PDP-8 is compact and light weight; it may be carried aboard ship by two people and may be easily mounted in standard equipment racks bolted to the deck. The PDP-8 is rugged. Actual cruises demonstrate the reliability of DEC computers as oceangoing instruments under the toughest conditions. PDP-8 is the successor to the PDP-5 and represents a six-fold increase in speed at a 30% reduction in price. PDP-5 oceanographic programs are essentially the same as PDP-8 programs and may be run faster on the PDP-8. There is no difference between the programming language of the PDP-5 and PDP-8, experience gained in PDP-5 installations is available to PDP-8 users via the DECUS program library.

Not only are DEC computers particularly suited for on-board applications, but they are truly general purpose scientific computers and are used in the leading scientific laboratories. The on-board computation may be made fully compatible with large scale computation center computers. The PDP-8 and DEC's other scientific computers, the large scale PDP-6 and medium scale PDP-7 are well suited for on-shore data reduction, analysis and computation.

LINC (for Laboratory Instrument Computer) was developed specifically for bio-science research and is available as a fully integrated laboratory computing system including general purpose analog to digital conversion equipment and oscilloscope display.



Atlantis II



Evergreen

ATLANTIS-II

The Atlantis II left Woods Hole on January 21, 1965 for a round the world expedition. The Indian Ocean phase of the voyage is part of a 23 nation experiment sponsored by UNESCO, in an effort to help the poverty-stricken nations of the Middle East increase their food supply by using the resources of the Indian Ocean. The 50,000 mile voyage included the following ports of call: Port Said; Bombay; the Serpelles Island; Fremantle, Australia, and Tokyo.

In addition to the UNESCO phase of the cruise, the Atlantis II collected hydrographic information used to chart currents, and geological information.

The Digital Equipment Corporation PDP-5 computer is being used around the clock for satellite navigation, hydrographic station data reduction, cruise data storage and retrieval, display of oceanographic data, analog to digital conversion and a variety of general purpose computational tasks. "The use of the computer as a real-time oceanographic tool has permitted us to make decisions on the basis of information that would not have been available otherwise. A large part of the scientific portion of the cruise has depended on computer-produced results," stated Atlantis II scientific personnel.

"The future course of computers at sea is limited more by the imagination of oceanographers in structuring questions than by the hardware available," stated Atlantis researchers.

EVERGREEN

From March to August the Evergreen participates in the International Ice Patrol season. The Evergreen's patrol consists of an oceanographic survey of the Grand Banks and Labrador Sea in March and April.



Aboard Atlantis II

USCG's oceanographic surveys in the vicinity of the Grand Banks are used principally for predicting the course and speed of sea ice and icebergs. It is mandatory that collected data be worked up as soon as possible.

Following a preliminary one-week evaluation while the Evergreen was engaged in search and rescue duties in the vicinity of Georges Bank and Cultivator Shoals of Massachusetts, the PDP-5 was used to process data tasks for about 500 oceanographic stations. About 400 casts of 13-to-18 bottles each were made for temperature and salinity down to 1,500 meters. In another 100 casts of 18-to-28 bottles each to 4,000 meters, oxygen determinations were also made. The DEC computer was used to record the data and make standard integration and scaling calculations for the determination of Sigma-T and Delta for standard depths. Not only did the computer show gains in the speed reliability, and precision with which data could be evaluated, but used on-line, it provided an immediate in situ check of instrumentation performance.

Specific comparisons show the speed advantages of machine over hand processing. Hand processing of the data for just one 13-bottle station takes about three hours, including corrective reversing thermometers, transcribing information, determining Sigma-T and the anomaly of specific volume, scaling for standard depth, calculating dynamic heights, and checking. Using the computer, these same procedures take about 15 minutes.

The computer was placed on board and installed in less than two hours and with relative ease. A small crane was used to hoist it aboard and lower it through a small hatch to the main deck. Its 390-pound weight created no problem, and since it was on casters it was readily wheeled down the narrow passageway to the oceanographic laboratory. Disregarding shock mounting, the computer was bolted directly to the deck — which happened to be right over the ship's main boiler. An ASR-33 typewriter input/output unit was mounted in a similar manner directly adjacent to the computer. The computer was then plugged into a standard 110-volt AC power outlet and turned on. The memory of this computer is non-destructive and the machine was able to perform the test routine that had been put in at the factory. On the 1964 computer evaluation cruise, winds often approached Beaufort scale 11, Sea State 9. At one point the ship rolled through 102° in six seconds.

While Evergreen was patrolling off Massachusetts, the following tests were performed — with no adverse effects on the computer's operation.

Line frequency was deliberately lowered and raised between 58 and 62 cps while the computer was operating.



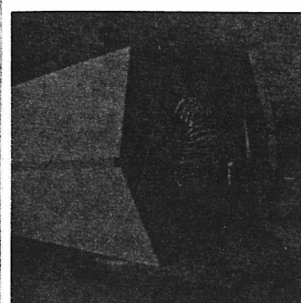
Pierce



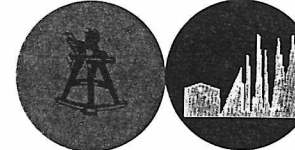
Brown Bear



Hudson Installation



Information International



Line voltage dropped to approximately 80 volts when heavy deck machinery was used.

Degaussing was employed in order to cancel the magnetic signature characteristics of the vessel.

Ship's radar and radio transmitters were used repeatedly with no ill effects, even though the antennas were comparatively close by.

Due to the inherent harmonics of a Diesel-electric power system, the ship vibrates constantly while underway. Again, no ill effects.

The computer was operated normally in a temperature range of 45°-to-90° without difficulty.

The only formal training received by Coast Guard personnel in the operation and maintenance of the computer was a one-week programming class and a two-week maintenance course conducted by Digital Equipment Corporation.

PIERCE

From the middle of March, 1965 to the end of July a PDP-5 computer was used solely to compute the position of the Pierce while the ship was engaged in hydrographic surveys. In July the computer was also harnessed to the task of on-line data processing and will continue to be used for both of these applications.

The Pierce's task consists of taking bathythermographs and Nansen bottle casts at specified locations in the Gulf Stream—part of a year-long Gulf Stream study being coordinated by the Coast and Geodetic Survey of the Environmental Science Service Administration. The computer programs used in this project consist of a temperature correction program. One of the programs corrected thermometer readings and determined the thermometric depths. Another program computed the specific volume and dynamic height from data obtained from a nansen bottle cast.

Two programs were used to determine the ship's position. The first program was used to convert hyperbolic lane count values obtained from a Decca Hi-Fix system to X-Y rectangular coordinates. This enabled the ship to easily plot its position while underway conducting a hydrographic survey. The manner in which this was performed was by the computer operator typing in the lane count on the ASR-33 values obtained from the Hi-Fix receiver. The computer then typed out on the same line the corresponding X/Y rectangular coordinates.

The second program was used to compute a hyperbolic lane count value from a three point fix. This was necessary in order to calibrate the Hi-Fix dials since the Hi-Fix system

only measures a fraction of a lane (up to approximately 87 meters) and the lanes themselves must be counted through a mechanical linkage on the Hi-Fix receiver. Thus when first starting to use the system or when an interruption occurs because of static, equipment failure, etc., a lane count value must be determined so as to correctly initialize the Hi-Fix dial readings. This program used sextant angles that were sighted on three known signal locations and whose X-Y coordinates were known.

This program then computed the ship's position in X-Y coordinates and further translated them to hyperbolic lane count values. These computed values were then compared to the lane count values taken and recorded simultaneously with the sextant angles; which thus lead to a correction that could be applied to the dial readings so as to obtain the correct dial setting.

BROWN BEAR

Last year the Brown Bear research vessel manned by University of Washington oceanographers used the PDP-5 computer for an expedition to collect physical and chemical and biophysical data which was obtained 800 miles off the coasts of Oregon, Washington and British Columbia. Previously, the data obtained on missions of this sort couldn't be processed until after the vessel returned to shore. By obtaining preliminary computations while at sea, the oceanographers were able to evaluate findings immediately and make changes in the cruise plan while underway.

HUDSON

A PDP-5 computer was installed aboard CSS Hudson by the Bedford Institute of Oceanography for trial and evaluation of the computer in processing the output from a geophysical data logging system. The ship sailed from Halifax March 8 and returned May 1, 1965. During this period two cross sections were run across the Atlantic and systematic surveys were run in a section of the Median Valley of the Mid-Atlantic Ridge and the Western Approaches to the United Kingdom.

The ship steamed approximately 12,000 nautical miles and during this period 3.3 million decimal digits of positional and geophysical data were logged automatically on 28,000 feet of one-inch, eight-level paper tape. Data logging of time, gravity and magnetics was accomplished by an off-line geophysical data logging system (GEODAL) developed by the Bedford Institute of Oceanography. When the ship was in range of a Decca Navigational System, deccometer readings were digitized and stored on the punched paper

tape. The tape was then used as an input to the computer.

On previous cruises, calculations were performed from the same basic system with seagoing personnel and desk calculators. Corrections were applied to the gravimeter readings for time lag, east-west component and absolute value of the ship's velocity. The latter corrections were established by computing the position of the ship from the Decca coordinates and velocity from successive positions and times. While at sea, a total of 522 hours of computer time was used for these calculations. The PDP-5 reliably handled the geophysical data with an increase in speed and flexibility.

Future plans for the shipborne system includes the use of a high speed paper tape and a Calcomp plotter. With these facilities it is likely that additional oceanographic parameters will be logged on future cruises of the ships from the Bedford Institute of Oceanography.

INFORMATION INTERNATIONAL

Information International Inc. is currently using DEC computers for automatic reading and analysis of Oceanographic film records with a fully automatic film reading system, known as a Programmable Film Reader. The system which uses a PDP-7 digital computer is able to scan and recognize a variety of scientific data recorded on film.

For several years, Information International has been using the Programmable Film Reading System to read and analyze data recorded on film by oceanographic current meters, under contract to the Woods Hole Oceanographic Institute, the U.S. Public Health Service, and similar activities. Current meters contain devices for automatically recording on film the direction and rate of flow of ocean or fresh water currents. Data is recorded on the film in the form of interrupted lines or bars. This data can be automatically scanned and analyzed by the film reading system. Output is recorded on magnetic tape; it consists of a digital transcription of the original data recorded on the film.

Oceanographic bathythermographs are used to record on film or similar media the temperatures of ocean water at various depths. These data are recorded in the form of a line or trace across a slightly curved grid coordinate system. Reading of large quantities of these traces by hand has been a tiresome and expensive process. The I.I.I. Programmable Film Reader System makes it possible to rapidly and automatically read and digitize these traces, at a rate far greater than human operators can achieve.

Another I.I.I. use of PDP-computers for oceanographic research is the World Oceanographic Data Display System.

The System is based on the use of a PDP digital computer with type 30 display, to enable a researcher to conduct an analysis of oceanographic data using a series of visual displays generated by a digital computer. The eventual goal of the program will be the design of a computer system capable of storing the entire body of world oceanographic data and making it available for visual display and analysis.

The researcher will be able to select specific data for display, in the form of contour lines against a map of a selected oceanic area. He will be able to vary the parameters of the data selected, and observe the resulting variations in the contour lines. It is anticipated that the world oceanographic data display system will open up the presently available body of oceanographic data to a rapid and meaningful analysis by oceanographic researchers.

A third oceanographic application for DEC computers at I.I.I. is the Vortex Ocean Model Program. This program also uses a DEC CRT Display and enables an oceanographic researcher to simulate the interaction of ocean vortices on the scope face. The researcher can control the configuration of the vortex simulation by appropriate data entries made by means of a typewriter connected to the computer. The value of any of the variables in the simulation may be changed at any time in this way during the course of the simulation. The number of vortices may be varied from one to thirty-one. Vortices may interact in either a circular or an unbounded ocean.

COMPUTER-PLOTTING SYSTEM

A PDP-8 computer coupled with a large flat-bed X-Y plotter will be used for precise Hydrographic Surveys. Coastal Charts that show bottom topography and specific sounding will be constructed from the information that is collected through this shipboard computer.

Geographic position information will be automatically introduced by one of the presently available precise systems for coastal hydrography. Soundings and other information, such as the Julian date and draft of the ship, will also be introduced directly to the computer. The computer will then automatically plot the course and soundings of the ship on the X-Y plotter and compare it against the desired projected track. Indicators sent to the helmsman from the computer will tell him if he is off the track and how to correct in order to place the ship back on the correct track.

In addition to the above, the computer will be used as a general purpose machine for a variety of hydrographic and oceanographic applications. Some of these applications will be plotting three position sextant angle fixes, and solving problems in geodesy.

PROGRAMMING AND INTERFACING A COMPUTER FOR OCEANOGRAPHIC APPLICATIONS WITH DATAK

DATAK is a programming aid which allows the oceanographer to format his data acquisition requirements in a simple language similar to algebra. It gives him a great deal of flexibility in choosing interface hardware. DATAK programs also allow him flexibility in choosing the frequency and conditions under which he samples the experimental environment as well as making it possible to add or change sensors without major reprogramming the computer. DATAK is currently available for the PDP-8.

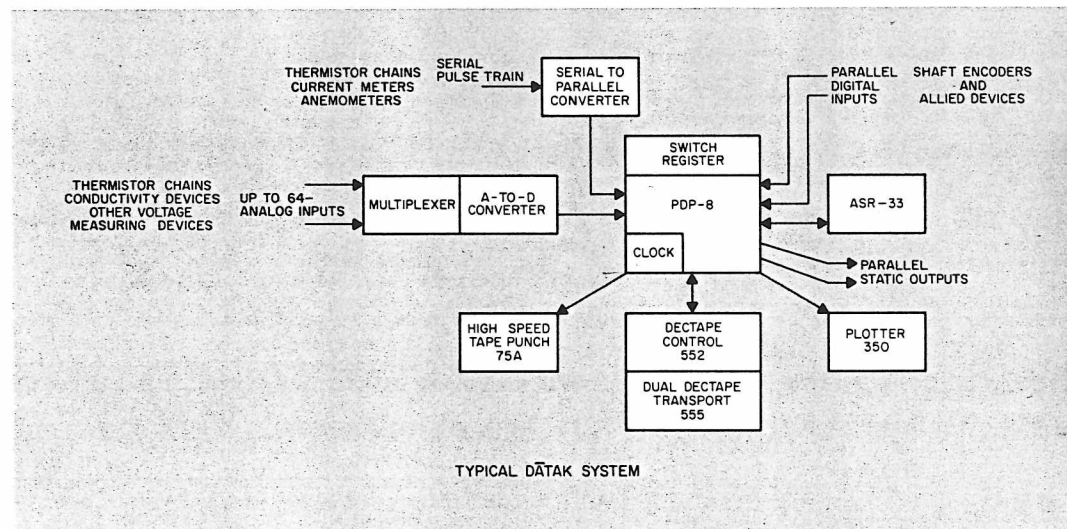
Special hardware buffers are available for each of the three kinds of data input which allow data from environmental sensors to enter the computer under control of the DATAK program. Data can come to the computer from digital-parallel inputs, serial inputs, and the multiplexed analog-digital inputs. DATAK gives the oceanographer the following flexibility when sampling the environment:

1. A variety of preprogrammed interface devices easily

connect computer directly to instrumentation.

2. Simple symbolic assignment of identifying names to physical input variables such as "Pressure," "Temperature."
3. Absolute control in sampling the experimental environment with respect to time.
4. Computer compatibility with respect to rapid response sensors using up to 176 separate sensing devices.
5. Capability to make logical decisions concerning the acquisition of data while sampling the environment.
6. Storage of data for future computations, as well as immediate output, for checking quality while obtaining data.

DATAK allows the investigator to analyze his sample using the following inputs.



- Up to 96 independent data variables using digital-parallel input.
- Up to 64 independent data variables using a multiplexed A-to-D converter.
- Up to 25 independent data variables via serial buffer input.

Each independent variable can be sampled at a rate of up to 100 times per second.

Data output can be distributed to a number of devices to allow immediate presentation as well as permanent storage. The following devices are available:

1. On-line teleprinter. Variables can be typed in decimal or octal.
2. High-speed paper tape punch. Variables can be punched in decimal or octal.
3. Digital's compact DECTape. Variables are recorded magnetically on DECTape in binary with identifying words.
4. X-Y plotter. The plotter pen is moved to a new position each time an output is specified.

Up to four digital outputs are available through parallel buffers to other devices such as relays, buffers, sense lines, and range switching devices.

AVAILABLE OCEANOGRAPHIC PROGRAMS

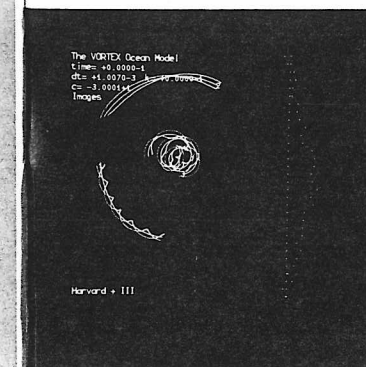
Oceanographic programs have been written for the PDP-8 which provide the oceanographer with a means of record-

ing pertinent surface environmental phenomena as well as recording subsurface values of temperature and salinity. These programs are ready to use. They allow easy transfer of data to standard NODC forms for transmission to the National Oceanographic Data Center.

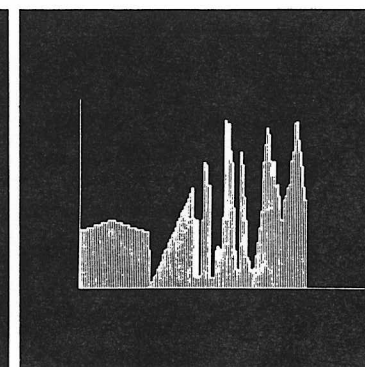
One program computes Sigma T, the anomaly of specific volume and sound velocity for each observed sample depth; allowing the oceanographer to examine the stability of the water mass prior to further computation. When the computer has calculated the last observed anomaly of specific volume, it proceeds to a scaled value format in which the oceanographer can scale temperature and salinity at any desired depth between observed data points.

Since there are two distinct interpolations using the observed values (two above, one below the desired scaled value and one above, two below the desired scaled value) there are two values each of temperature and salinity that are scaled. The average of the two interpolated values is also calculated, resulting in a total of three values each of temperature and salinity. The oceanographer then chooses one of the calculated scaled values for temperature and one for salinity and the computer determines Sigma-T and the anomaly of specific volume for the chosen values.

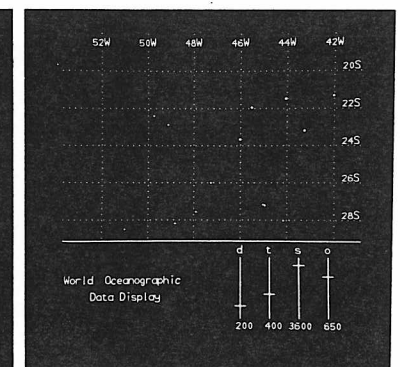
In addition, the varied oceanographic programs that have been written and are being written by DEC computer users are available through DECUS, the Digital Equipment Corporation Users Society.



Mathematical Vortex Ocean Model Generated and Displayed on DEC Computers



Histogram of Ocean Current Speed Read From Film and Displayed on DEC Computers

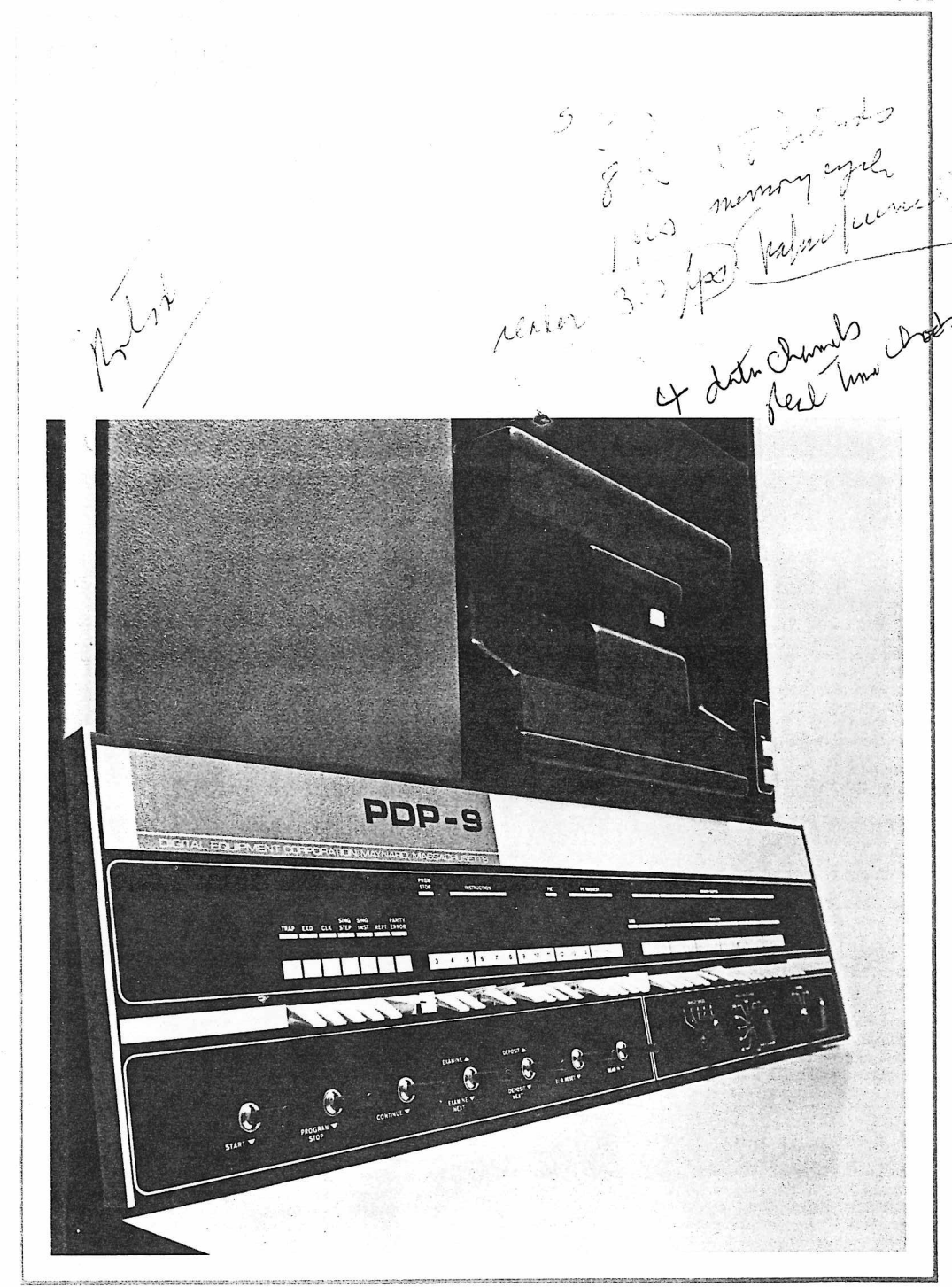


Computer Library System of Retrieving and Displaying Oceanographic Station Data

DIGITAL

EQUIPMENT
CORPORATION
MAYNARD, MASSACHUSETTS

Cambridge, Mass. • Washington, D. C. • Parsippany, N.J.
Rochester, N.Y. • Los Angeles • Palo Alto • Chicago • Ann
Arbor • Pittsburgh • Denver • Huntsville • Orlando
Carleton Place and Toronto, Ont. • Reading, England • Paris,
France • Munich and Cologne, Germany • Sydney, Australia



DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

PDP-9 ... the big one in the low price field

The big features of the PDP-9 provide greater processing power than any other computer in its price class. The PDP-9's 18 bit word length provides greater accuracy per word and simpler programming than the smaller word length machines. A PDP-9 18 bit word can directly and simply address a full 8192 word memory module. The hardware is there to do on-line control, data reduction and computation without round-about programming. PDP-9 modular software expands to use the machine fully.

Starting with the basic PDP-9, the researcher or systems designer can have full system power without add-on's. When he wishes his system to grow, the PDP-9 has both the standard options and modular software to do it.

PDP-9 BEGINS BIG

The basic PDP-9 computer system has an 8,192 word ferrite core memory, bi-directional input/output bus, direct memory access channel (with true cycle stealing), and four high speed data channels. The 18 bit word can have an optional parity bit. There is a high speed control memory, a high speed adder and a real-time clock. The basic PDP-9 also has a 300 character-per-second paper tape reader, a 50 character per second paper tape punch and input/output teleprinter. All 8,192 words are directly addressable. I/O transfer rate up to 18,000,000 bits per second; add time is two microseconds. Hardware and software are ready now. All this in the low price field.

PDP-9 EXPANDS BIG

The basic PDP-9 expands with powerful central processor options, 8,192 word memory modules and a wide variety of input/output options. Core memory expands up to 32,768 words. Bulk storage devices include low cost DECTape and IBM compatible magnetic tape. Input/output devices, such as DEC's own A/D converters and CRT displays, may either be attached to the I/O bus and use programmed or data

channel transfers or be interfaced to the direct memory access bus for one-cycle, true cycle-stealing, direct transfers to memory. Configurations are easily tailored with standard options. Special devices are easily and economically interfaced with standard FLIP CHIP™ circuit modules.

To take full advantage of the expanded PDP-9 systems, the PDP-9 has a modular device-independent software package.

BIG PDP-9 SOFTWARE

PDP-9 basic software is completely compatible with software available on the popular PDP-7. The PDP-9 Extended Software Package makes full use of expanded PDP-9 configurations. New software includes real-time FORTRAN IV, a versatile macro assembler, a control monitor, a 6 and 9 digit floating point arithmetic package, an on-line editor, an on-line debugging system, and a modular I/O programming system that eliminates the need to program standard peripheral devices.

BIG BACKGROUND IN RESEARCH AND ENGINEERING

The PDP-9 is a direct lineal descendant of the PDP-1, PDP-4, and PDP-7. DEC's 18 bit word computers have established an important community that share programs and techniques through one of the most effective user's groups in the computer field.

Over a thousand DEC computers are being used in on-line research and engineering alone. DEC's background of experience in your field results in one of your most important assets: the DEC field engineer. He is prepared to discuss your requirements in light of hundreds of the on-line data taking and control problems similar to your own. He has applications literature and the names of others using computers in your field; his phone number is listed on the back cover of this brochure.



BIG PDP-9 CENTRAL PROCESSOR

Figure 3 illustrates the basic organization of the PDP-9 central processor. Using a transfer bus system, data is transferred between registers with DC levels to minimize timing problems (level logic is used in the central processor). All active registers use simple circuit designs, there are no logical delays.

FEATURES

Control Memory — The Control Memory is a very fast read-only, prewired magnetic core storage unit. It stores all sequences of internal micro-instructions required to fetch and execute a program's instructions, to effect operation of the data channels, and to respond to operator commands initiated at the control console.

High Speed Adder — The 19-bit Adder functions as a fast adder-subtractor for arithmetic operations, and as the transfer path for all inter-register transfers and shift operations. It can add two 19-bit words in 200 nanoseconds.

Real-time Clock — The Real-time Clock generates a pulse every 16.7 milliseconds for 60-cycle systems (every 20.0 milliseconds for 50-cycle) and automatically increments location 00007. It may be used as either an elapsed time counter or an interval timer. When overflow of location 00007 occurs, the clock requests a program interrupt which can be used to transfer control to a subroutine.

Convenient Control Console — The Control Console (or operator's console) contains the keys, switches, and lights required for operator initiation, control, and monitoring of programs. Some of the features of this console are:

- A read-in switch to initiate the reading of paper tapes
- Single-step and single-instruction switches
- REGISTER indicators and REGISTER DISPLAY switch that allow continual monitoring of key points in the system such as the accumulator, arithmetic register, memory quotient, program counter, input/output bus, paper tape reader buffer, paper tape punch buffer, teletype buffer, and input/output status flags
- EXAMINE and EXAMINE NEXT switches that allow the manual examination of the contents of any memory location
- 18-switch register for manual entry of data and instructions or sense-switch capabilities

ELEMENTS

Accumulator — The PDP-9 Accumulator, an 18-bit register, retains the results of arithmetic/logical operations for the interim between instructions.

Link — A one-bit register, the link acts as an extension of the Accumulator. Its contents may be program sampled and program modified.

Arithmetic Register — The Arithmetic Register functions with the Accumulator to perform arithmetic and logical operations.

Timing Control — The Timing Control generates clock signals governing the timing of internal processor operations and the synchronization of core memory and input/output devices to these operations.

Control Register — The Control Register delivers control signals to the transfer busses and to the active registers.

Multiplier-Quotient Register — The optional Extended Arithmetic Element adds the 18-bit Memory Quotient Register

to the basic PDP-9 for double-precision products in multiplication and dividends in division.

Program Counter — The Program Counter retains the address of the next instruction to be executed.

Instruction Register — The Instruction Register accepts the instruction code of each word fetched from memory and supplies it to the Control Memory.

Memory Buffer Register — The Memory Buffer Register is the interface for information transfers between the processor and memory.

PDP-9 CENTRAL PROCESSOR OPTIONS

Extended Arithmetic Element — The Extended Arithmetic Element adds high-speed multiply, divide, normalize, and shifting instructions to the basic PDP-9. Typical operation times (depending on number of steps specified) are:

Multiply — 3 to 11 microseconds

Divide — 3 to 11 microseconds

Normalize — 2 to 17 microseconds

Shift — 2 to 17 microseconds

Memory Extension Control — Memory Extension Control, a prewired PDP-9 option, extends PDP-9 addressing capability to permit addition of up to three additional 8,192-word core memory modules, for a system total of 32,768 words.

Power Failure Protection — With the power failure protection option added, PDP-9 is not affected by line power interrupts of less than 25 milliseconds duration. An interrupt of greater duration initiates a program interrupt in which a subroutine can save the contents of active registers (Accumulator, Multiplier-Quotient, Program Counter, Link). A restart provision allows automatic program resumption following the return of line power.

BIG PDP-9 CORE MEMORY

The PDP-9 core memory uses a new 2½D flat pack design concept and operates with a cycle time of 1.0 microsecond; add time is 2.0 microseconds.

Each 8,192-word core memory module contains a core stack, sense amplifiers, drivers, and a memory address register. The latter sets up the memory location (address) to be used for data retrieval or storage.

System core memory can be expanded from the basic 8,192 words up to 32,768 words in 8,192-word increments. Such expansion requires the memory extension control to extend PDP-9's addressing capability.

Direct Memory Access Channel

Each PDP-9 memory module has a two-port capability for data entry and retrieval. One port, connecting to the memory bus, services the processor. The other allows direct and immediate access of memory by a peripheral device for fast data transfers via a direct memory access bus. A device request for direct memory access service has priority over a processor or program request.

Parity Option

Parity checking may be optionally added to each memory module (word length is increased to 19 bits). A control on the processor console allows the program to be stopped upon detection of a parity error at the programmer's option.

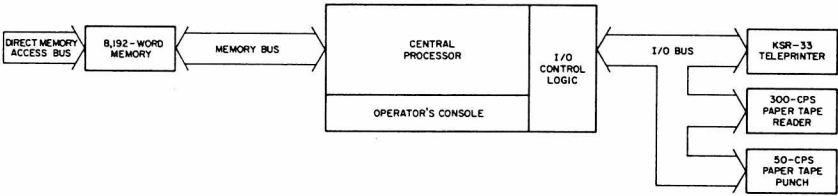


Figure 1 Basic PDP-9

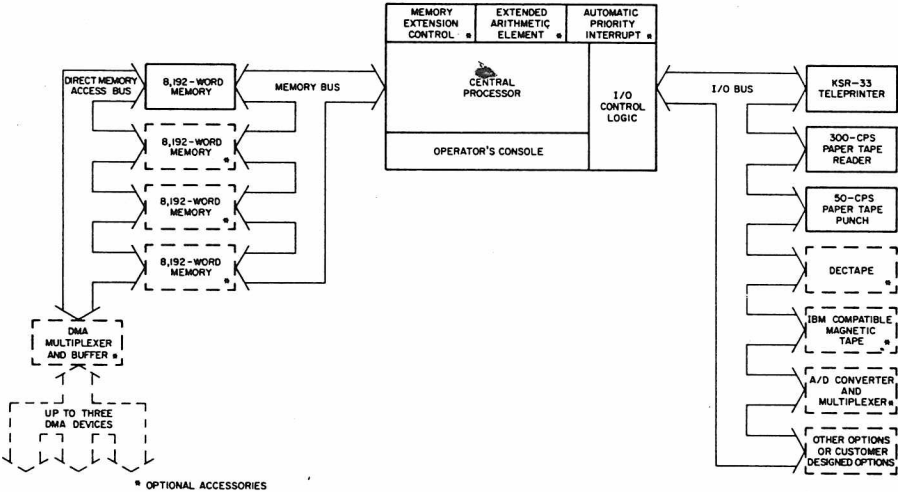


Figure 2 Expanded System Configuration

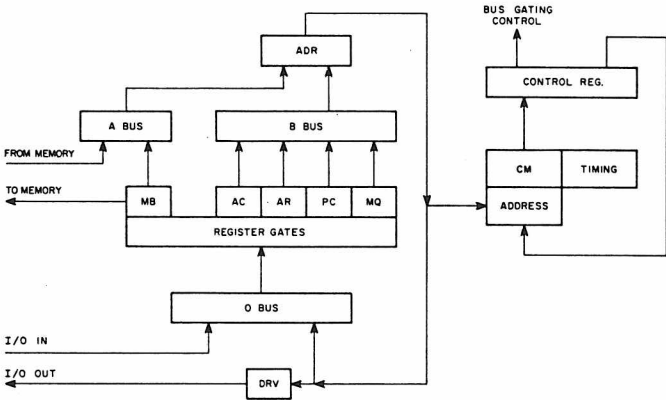


Figure 3 Central Processor Organization

BIG INPUT/OUTPUT FACILITIES

PDP-9 Input/Output devices may be attached to either the bidirectional Input/Output Bus or the Direct Memory Access Channel. The Input/Output Bus can be used for all programmed transfers and data channel transfers, while the Direct Memory Access Channel is used for extremely fast (50,000-1,000,000 wps) devices that must have immediate access to memory.

Input/Output Bus

The Input/Output Bus is a set of data and control lines that serially link peripheral device controls to the central processor. It can select any one of sixty-four (64) devices, and up to four (4) sub-devices within any device. Up to three (3) Input/Output pulses can be issued to any device, so that $(64 \times 4 \times 3 =) 768$ different Input/Output commands are available on the bus.

Data Transfers

Input/Output data transfers function within the following priority structure.

1. Direct Memory Access Channel requests (highest priority)
2. Data Channel requests
3. Priority interrupts (8 levels) — optional
4. Program interrupts
5. Main program

A higher priority request for service interrupts any in-process service of a lower priority at the end of the current instruction, or, in the case of the Direct Memory Access Channel, at the end of the current memory cycle. Program interrupts and priority interrupts require the main program transfer control to service subroutines. These routines restore the program's control at completion of the service interval. Data Channel requests are satisfied by computer-granted data breaks; i.e., program execution is delayed while the Data Channel transfers information between memory and the requesting device via the Memory Buffer Register. The Direct Memory Access Channel operates on a true cycle stealing basis.

Direct Memory Access Channel

The Direct Memory Access Channel bypasses the central processor to provide a data path between system core memory and high-speed peripherals. Up to three devices can be concurrently serviced by the addition of an optional multiplexer which establishes a priority relationship for the devices. The Direct Memory Access Channel functions on a "cycle stealing" basis; i.e., a device request for service defers execution of the main program for one memory cycle, during which time a word is transferred to or from core memory. Program execution resumes upon completion of the

transfer cycle. The Direct Memory Access Channel accesses memory through its own entry port to each memory module.

Data Channels

Data Channel operations use the Input/Output Bus for data transfers between core memory and high data rate peripherals (DECtape, magnetic tape, etc.). The Data Channel facility will concurrently service up to four devices and can be expanded to eight devices; priority is established at the hardware interface.

The channels function with processor-granted data breaks to interleave transfers with execution of the program in progress. Data is read into memory in three cycles and out of memory in four cycles.

Program Controlled Transfers

Program controlled transfers are made by Input/Output Transfer (IOT) instructions contained in the main program or in service subroutines. These instructions are microcoded to effect response only for a particular device. The microcoding includes issuing of a unique device selection code and appropriate processor-generated pulses to initiate the specified operation.

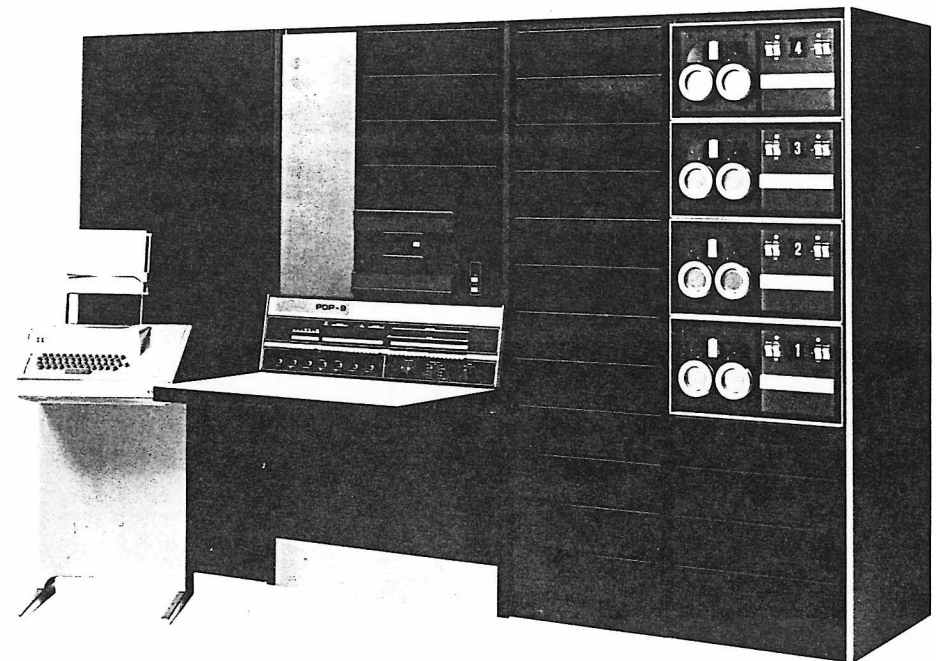
For an "out" transfer, the program reads a data word from memory and places it on the Input/Output Bus. A subsequent Input/Output Transfer instruction selects the device and causes it to enter the word in its data buffer register. For an "in" transfer, the process reverses. An Input/Output Transfer instruction selects the device and causes the contents of its data buffer to be gated onto the Input/Output Bus. In turn, the word is strobed into the accumulator and stored, by the program, in memory.

Program Interrupt

The program interrupt facility offers an efficient method of Input/Output servicing. The computer continues with execution of a program until a peripheral signals that service is required. At that time, the program in process is interrupted and control transfers to a service subroutine.

Automatic Priority Interrupt Option

The 32 channel Automatic Priority Interrupt system extends the PDP-9's Input/Output capabilities to include priority servicing of peripherals, a useful feature for programs operating in real-time environments. The Automatic Priority Interrupt has eight ranged levels of priority; each takes precedence over lower automatic priority interrupt levels, program interrupts, and the main program. This priority structure permits high data rate or critical devices to interrupt servicing of slower or less critical devices with minimum program "overhead". The four higher levels are for fast access to Input/Output service subroutines in response to device-initiated service requests. Each of these levels permit multiplexing, i.e., up to eight devices may be assigned equal priority. The four lower automatic priority interrupt levels are assigned to the processor. Activity on them is limited to program-initiated requests for transferring control to programs or subroutines on a priority basis.



BIG PERIPHERAL OPTIONS

Mass Storage Devices

DECtape Control Type TC02 and Transport TYPE TU55

The DECTape system provides a unique fixed-address magnetic tape facility for program and data storage. The DECTape Control transfers direct to memory via the Data Channel facility and can handle up to eight transports. Each transport stores 3,000,000 bits of information at 375 bpi and 80 ips.

Magnetic Tape Control Type TC59 and Transport Type 545

The Automatic Magnetic Tape Control transfers data to and from IBM-compatible magnetic tape transports via the Data Channel facility. Each control can handle up to eight transports and can read or write in BCD or binary modes. The Type 545 transport can handle 7-channel tapes at 200,556, and 800 bpi and 45 ips. A 75 ips transport will also be offered.

Magnetic Drum System Type RM09

Operates through the Direct Memory Access Channel for true cycle-stealing access to memory. Available in 32,768-word, 65,536-word, and 131,072-word sizes.

Display Systems and Accessories

Precision CRT Display Type 30D

Plots data point by point on a 16-inch cathode ray tube in a raster $9\frac{3}{8}$ inches square having 1024 points on a side. Separately variable 10-bit X and Y coordinates. Includes program intensity control. Plotting rate is 35 microseconds per point.

Oscilloscope Display Type 34H

Controls the plotting of data point by point on an X-Y plotting scope such as the Tektronix Model RM 503. Raster size is 1024 x 1024 points.

Programmed Buffered Display Type 339

Interfaces to PDP-9 to provide up to 1400 inches of vector (20,000 points) or 1200 characters flicker free on $9\frac{3}{8}$ -inch square raster. System includes DMA Multiplexer Adapter, High Speed Light Pen, and push-button function box. Character generator, zoom option, search option, and slave mode available as extras.

Precision Incremental CRT Display Type 340

Plots points, lines, vectors, and characters on a 1024 x 1024 raster $9\frac{3}{8}$ inches square. Plotting rate is $1\frac{1}{2}$ microseconds per point in vector, increment, and character modes, while random point plotting takes 35 microseconds. Interfaces to Direct Memory Access Channel via DMA Multiplexer Adapter.

High Speed Light Pen Type 370

Uses fiber optic light pipe and photomultiplier system for fast detection and modification of information displayed on the precision CRT display.

Card Input Equipment

Card Reader and Control Type CR01E

Reads standard 80-column cards at 100 cpm. Bin capacity for 430 cards.

Card Reader and Control Type CR02B

Reads standard 80-column cards at 200 cpm in binary or alphanumeric modes.

Line Printers and Plotters

Line Printer and Control Type 64

Prints 120 columns, 64 characters per column. Available at 300 and 600 lines per minute. Includes 120-character buffer.

Incremental Plotter and Control Type 350

Performs high resolution plotting on paper 12 or 31 inches wide at rates of 12,000 or 18,000 points per minute. Plotting increments are 0.005 and 0.01 inch.

Data Communications Systems

Multiple Teletype System Type LT09

Provides inexpensive interface to PDP-9 for up to five teletypes (KSR-33, ASR-33, KSR-35, or ASR-35). Several LT09 units may be attached to the PDP-9.

Data Communications System Type 680

Provides high-capacity data communications system without tying up PDP-9 central processor. Includes PDP-8 in Type 680 system, interfaced to PDP-9 via Interprocessor Buffer, Type DB98A. Can handle up to 128 teletype stations.

Analog-to-Digital Converters

General Purpose Analog-to-Digital Converter Type 138E

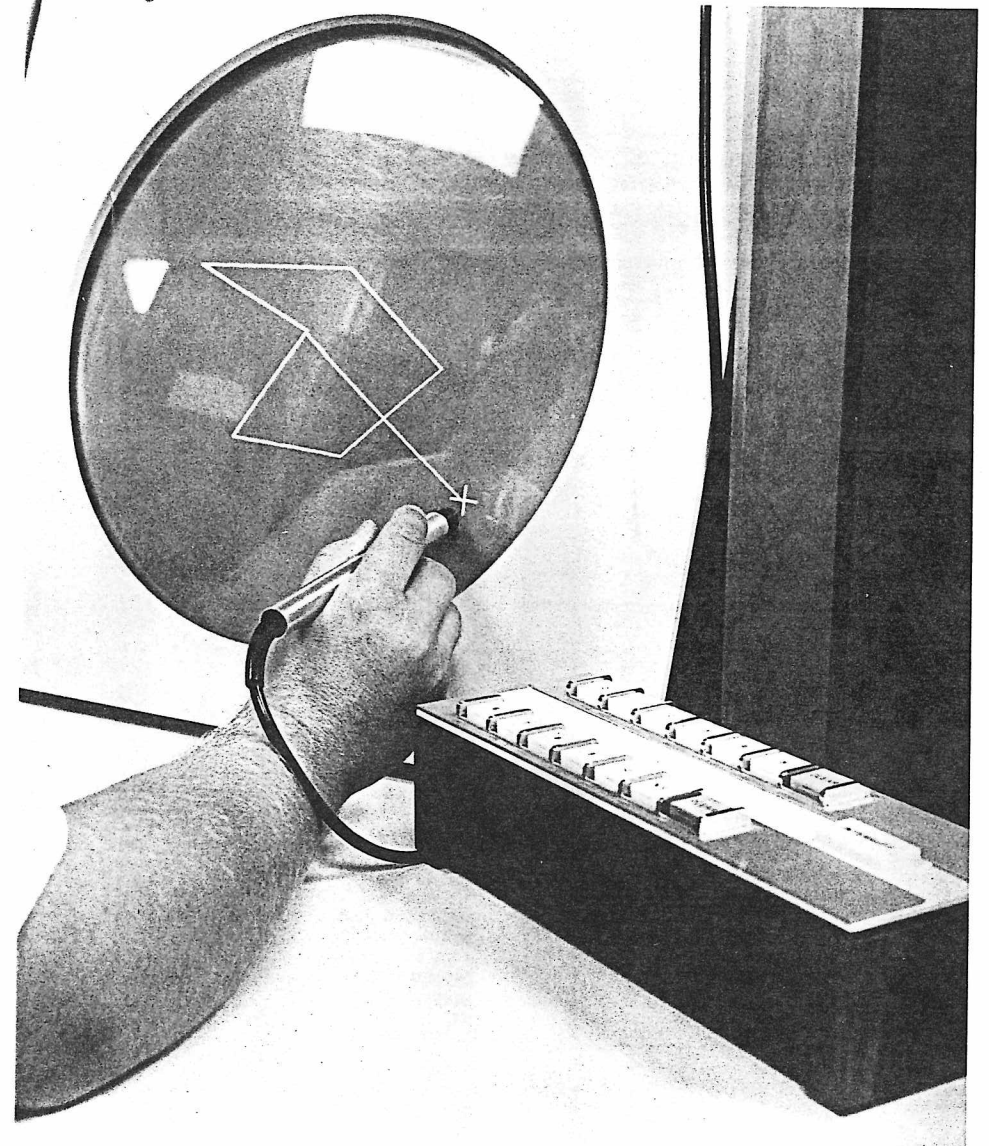
The Type 138E is a high-speed, successive approximation converter with switch-selected word length from 6 to 12 bits and switch-selected error from $\pm 0.8\%$ to $\pm 0.025\%$. Conversion time varies from 9 to 35 microseconds according to these switch settings. Analog input signal range is 0 to -10 volts.

General Purpose Multiplexer and Control Type 139E

Up to 64 analog input channels can be selected for application to the input of the Type 138E by the Type 139E. Channels can be program selected in sequence or by individual address. The number of channels that can be selected is determined by the number of optional Multiplexer Switches Type A100 used in the Type 139E. Each Type A100 can select two channels.

Digital-To-Analog Converter Type AA01A

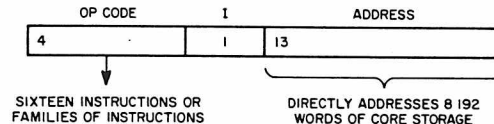
The Type AA01A D/A converter is used to convert 12-bit binary numbers to analog voltages. There are three separate converters and three digital buffer registers in each AA01A. Register updating is accomplished through one 12-bit input channel.



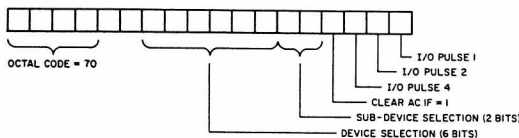
BIG PDP-9 INSTRUCTION REPERTOIRE

PDP-9 Order Code

The PDP-9 eighteen-bit word is decoded as shown below:



Of the 16 instruction codes available, 13 are memory-reference instructions and use the format shown above. Of the other three, one provides for the "Operate" group of micro-programmed instructions that includes CLEAR ACCUMULATOR, SKIP ON POSITIVE, SKIP ON NEGATIVE, CLEAR LINK, ROTATE, etc. Another provides for the family of instructions that control the optional Extended Arithmetic Element and adds MULTIPLY, DIVIDE, LONG SHIFT, and NORMALIZE instructions to the basic set. The last operation code provides the family of input-output (IOT) instructions which can handle up to 256 devices, with up to three separate pulses per device. The IOT instructions can be micro-programmed to clear the accumulator and issue one, two, or three pulses per word. An IOT instruction format is shown below.



Addressing Modes

Memory reference instructions can use direct or indirect addressing. When a PDP-9 system contains more than 8,192 words of core storage, the Extend Mode is used to address the additional memory banks.

Direct Addressing — 8,192 words of any one memory module in the system can be directly addressed. Locations not in the current 8,192-word memory block are accessed by indirect addressing operation of the memory extension control option.

Indirect Addressing — When indirect addressing is indicated, the addressed memory location is taken as not containing the operand, but the address at which the operand is located. Only one level of indirect addressing is permitted. When in Extend Mode, 15 bits of the indirect word are used as the address, permitting all 32,768 possible words to be accessed.

Extend Mode Addressing — With extend mode, locations not in the same 8,192-word core memory block can be accessed by indirect addressing. Bits 3 and 4 of the indirect word indicate the block in which a location addressed by bits 5-17 resides.

Auto-Index Registers

Eight locations (10-17) of the 8,192-word module included in the standard PDP-9 configuration act as auto-index registers. When indirectly addressed, the contents of an auto-index register are incremented by one and then taken as the effective address of an instruction. When directly addressed, these locations act like all other memory locations.

INSTRUCTIONS

MEMORY REFERENCE INSTRUCTIONS		MNEMONIC	OPERATION
MNEMONIC	OPERATION	LRSS	long right shift, signed
CAL Y	call subroutine. Y is ignored jms 20 if bit 4 = 0, jms i 20 if bit 4 = 1.	LLS	long left shift
DAC Y	deposit AC. C(AC) = > C(Y)	LLSS	long left shift, signed
JMS Y	jump to subroutine. C(PC) = > C(Y ₁₇), C(L) = > C(Y ₂), Y + 1 = > C(PC)	ALS	accumulator left shift
DZM Y	deposit zero in memory. 0 = > C(Y)	ALSS	accumulator left shift, signed
LAC Y	load AC. C(Y) = > C(AC)	NORM	normalize: max. shift is 44
XOR Y	exclusive OR. C(AC) V C(Y) = > C(AC)	NORMS	normalize, signed
ADD Y	add (1's complement). C(AC) + C(Y) = > C(AC)	MUL	multiply unsigned
TAD Y	2's complement add. C(AC) + C(Y) = > C(AC)	MULS	multiply signed
XCT Y	execute.	DIV	divide C(AC and MQ) as a 36-bit unsigned number
ISZ Y	index and skip if 0. C(Y) + 1 = > C(Y), if C(Y) + 1 = 0, then C(PC) + 1 = > C(PC)	DIVS	divide C(AC and MQ) as a 34-bit 1's complement signed number
AND Y	AND. C(AC) C(Y) = > C(AC)	IDIV	integer divide unsigned
SAD Y	skip if AC and Y differ. If C(AC) ≠ C(Y), then C(PC) + 1 = > C(PC)	IDIVS	integer divide, signed
JMP Y	jump. Y = > C(PC)	FRDIV	fraction divide unsigned
OPERATE INSTRUCTIONS		FRDIVS	fraction divide, signed
MNEMONIC	OPERATION	LACQ	replace the C(AC) with the C(MQ)
OPR	operate	LACS	replace the C(AC) with the C(SC)
NOP	no operation	CLQ	clear MQ
CMA	complement, C(AC) = > C(AC)	ABS	place absolute value of AC in the AC
CML	complement link, C(L) = > C(L)	GSM	place AC sign in link and take absolute value of AC
OAS	inclusive OR AC switches C(ACS) V C(AC) = > C(AC)	OSC	inclusive OR the SC into the AC
LAS	load AC from switches C(ACS) = > C(AC)	OMQ	inclusive OR AC with MQ and place results in AC
RAL	rotate AC + link left one place C(AC _i) = > C(AC _{i-1}), C(L) = > C(AC ₁₇), C(AC ₀) = > C(L)	CMQ	complement the MQ
RCL	clear link, then ral. 0 = > C(L), then ral	IOT INSTRUCTIONS	
RTL	rotate AC left twice. Same as two ral instructions	MNEMONIC	OPERATION
RAR	rotate AC + link right one place. C(AC _i) = > C(AC _{i+1}), C(L) = > C(AC ₀), C(AC ₁₇) = > C(L)	Program Interrupt	
RCR	clear link, then rar. 0 = > C(L), then rar	IOF	turn off interrupt
RTR	rotate AC right twice. Same as two rar instructions	ION	turn on interrupt
HLT	halt. 0 = > RUN	ITON	turn on trap, also turns on program interrupt
SZA	skip on zero AC. Skip if C(AC) = positive zero	IO Equipment	
SNA	skip on non-zero AC. Skip if C(AC) ≠ positive zero	IOFS	read status of io equipment
SPA	skip on positive AC. Skip if C(AC ₀) = 0	Clock	
SMA	skip on negative AC. Skip if C(AC ₀) = 1	CLSF	skip if clock flag is 1
SZL	skip on zero link. Skip if C(L) = 0	CLOF	turn off clock, clear clock flag
SNL	skip on non-zero link. Skip if C(L) = 1	CLON	turn on clock, clear clock flag
SKP	skip, unconditional. Always skip	Paper Tape Reader	
CLL	clear link. 0 = > C(L)	RSF	skip if reader flag is a 1
STL	set the link. 1 = > L	RSA	select reader for alphanumeric, clear reader flag
CLA	clear AC. 0 = > C(AC)	RSB	select reader for binary, clear reader flag
CLC	clear and complement AC. -0 = > C(AC)	RRB	read the reader buffer into AC, clear reader flag
GLK	get link. 0 = > C(AC), C(L) = > C(AC ₁₇)	Paper Tape Punch	
LAW N	load AC with law N, where N equals a constant. law N = > C(AC)	PSF	skip if punch flag is a 1
EAE INSTRUCTIONS		PLS	punch a line in alphanumeric mode
MNEMONIC	OPERATION	PCF	clear punch flag
EAE	basis EAE command — no operation	PSB	punch a line in binary mode
LRS	long right shift	Keyboard Input from Teleprinter	
		KSF	skip if keyboard flag is a 1
		KRB	read the keyboard buffer into the AC, clear key- board flag
		Teleprinter	
		TSF	skip if teleprinter flag is a 1
		TLS	load teleprinter buffer and select, clear teleprinter flag
		TCF	clear the teleprinter flag

Software Design Philosophy

Two complete software systems and a maintenance system are available with PDP-9 systems. All three have been designed to meet the following requirements:

Modularity — so that all hardware options present on a system may be utilized.

Sophisticated techniques — to supply the power and versatility required by experienced programmers with complex applications and systems.

Ease of use — so that they are readily understandable and usable by the programming novice. For many applications PDP-9 software will allow problems to be solved the day the computer is delivered.

Basic Software Package

The PDP-9 Basic Software Package provides powerful single-job capabilities to the user of a basic system. Using the basic PDP-9 with an 8,192 word memory, paper tape reader, punch, and teletype, the Basic Software Package is compatible with software available for the current PDP-7.

This system includes both FORTRAN II and IV compilers, an assembler, input-output routines, arithmetic packages, a symbolic tape editor and a debugging system. All input and output for the Basic Software Package is paper-tape-oriented.

Extended Programming System

The extended programming system consists of an executive (monitor) program, an input/output programming system, and the following programming aids: a FORTRAN IV compiler (exceeds ASA standard), a macro assembler, peripheral interchange program, editor, debugging (DDT) program, and relocatable loader. This system affords the most efficient use of peripherals and allows automatic updating of programs to employ standard peripherals added in the future. Additional characteristics are:

1. Rapid, efficient retrieval of any system or user program from the system library.
2. Use of the standard system programs in such a manner that they can accept source data from an output data to any peripheral device.
3. Automatic linkages to correct peripheral equipment at the time a program is loaded.
4. Completely written and debugged input/output routines for use of any peripheral equipment from the most basic device independent subroutine. Automatic buffer handling and code conversion is included when desired. The package completely obsoletes the need for the programmer to concern himself with the peculiarities of specific I/O equipment and allows him to concentrate on the more functional portions of his program.
5. All programs and subroutines are relocatable and make most efficient use of the automatic priority interrupt, extended memory, and extended arithmetic element options.
6. Minimal resident memory requirements.
7. Consistency of control information and internal character code between programs.
8. Minimal specification of control information required.
9. Automatic return to the monitor system.

Descriptions of the major components follow.

I/O Programming System (IOPS)

IOPS provides a standardized programming interface to all I/O devices attached to the PDP-9 system. Symbolic input/output unit assignments allow user programs to select I/O devices specified symbolically to the macro assembler or the FORTRAN IV compiler. IOPS consists of a modular collection of relocatable input/output and utility subroutines which transmit data to and from peripheral devices and make the data readily available for processing. IOPS will be

coded on the data and file handling levels to provide device independence for all systems programs.

Specifically, IOPS provides the user with three levels of I/O programs.

1. **Device Handling** — Providing the basic subroutines to allow the user to operate a device, doing code conversion where required.
2. **Data Handling** — Providing the data buffering and internal line and character transmission facilities.
3. **File Handling** — Providing for the manipulation of named files on the system level.

IOPS completely eliminates the need for the programmer to program the standard peripheral devices. The programmer is no longer concerned with input/output problems such as timing, overlap, and differences in the characteristics of peripheral devices. This permits him to concentrate on his primary task — the processing of data inside the computer.

IOPS is coded on a modular basis to allow addition of new devices and modifications to the handling of current devices. It requires considerably less effort to modify an IOPS sub-program than to revise individual input/output sections to fit a new configuration. If IOPS is used, programs can be changed more rapidly to fit the expanded configuration.

FORTRAN IV Compiler

The FORTRAN IV compiler translates source programs into object programs acceptable to the linking loader. Comprehensive source language diagnostics are output by the compiler if language errors exist in the source program. It operates in the interrupt mode during compilation so that information is immediately available to the processor alleviating the need to wait for peripheral devices. In addition, it generates an object program capable of transferring data from peripherals via the interrupt, buffering it, and making it immediately available to the program. Lastly, the compiler reads source programs from any input unit and writes listings and object programs on any output unit.

The operating system performs input/output and arithmetic functions as directed by the object program at runtime. The real-time capabilities of the operating system include the ability to control buffering and the ability to directly communicate with IOPS interrupt service subroutines.

Macro-9 Assembler

Macro-9 is a two-pass assembler offering facilities beyond the PDP-9 symbolic assembler.

The Macro-9 assembler accepts programs written in the PDP-9 symbolic assembler language, and allows use of nested, recursive, and self-redefining macro and conditional assembly.

Relocatable Linking Loader

The linking loader can load any Macro-9 or FORTRAN IV object program from any input device, set up symbol tables for debugging, load programs into extended memory, automatically load and link system subroutines (including IOPS) from the system library.

Conditional loading of separately relocatable segments within one source program is available to allow loading only those functional elements or parameters of a subroutine actually required.

Maintenance and Diagnostic Programs

With the PDP-9, a new philosophy in maintenance and diagnostic programs will be offered. The PDP-9 Maintenance Package is designed to allow the customer to pin-point possible failures to the individual card — and in some cases to the function of a card — in a matter of minutes and without using an oscilloscope. Starting with several easily-tested assumptions about the Control Memory, the PDP-9 Maintenance programs check each computer function in order and in a pattern designed to yield a maximum amount of information as to the source of possible trouble.



DIGITAL SALES AND SERVICE

MAIN OFFICE AND PLANT

146 Main Street, Maynard, Massachusetts 01754
Telephone: From Metropolitan Boston: 646-8600
Elsewhere: AC617-897-8821
TWX: 710-347-0212 Cable: Digital Mayn. Telex: 092-027

DIGITAL SALES OFFICES

NORTHEAST OFFICE:

146 Main Street, Maynard, Massachusetts 01754
Telephone: AC617-646-8600 TWX: 710-347-0212

NEW YORK OFFICE:

1259 Route 46, Parsippany, New Jersey 07054
Telephone: AC201-335-0710 TWX: 510-235-8319

WASHINGTON OFFICE:

1430 K. Street, NW, Washington, D. C. 20005
Telephone: AC202-628-4262 TWX: 710-822-9435

SOUTHEAST OFFICE:

Suite 21, Holiday Office Center
3322 Memorial Parkway, S.W., Huntsville, Ala. 3580
Telephone AC205-881-7730 TWX: 205-533-1267

ORLANDO OFFICE:

1510 E. Colonial Drive, Orlando, Florida 32803
Telephone: AC305-422-4511

PITTSBURGH OFFICE:

300 Seco Road, Monroeville, Pennsylvania 15146
Telephone: AC412-351-0700 TWX: 412-372-4695

CHICAGO OFFICE:

910 North Busse Highway, Park Ridge, Illinois 60068
Telephone: AC312-825-6626 TWX: 312-823-3572

ANN ARBOR OFFICE:

3853 Research Park Drive, Ann Arbor, Mich. 48104
Telephone: AC313-761-1150 TWX: 810-223-6053

LOS ANGELES OFFICE:

8939 Sepulveda Boulevard, Los Angeles, Calif. 90045
Telephone: AC213-670-0690 TWX: 910-328-6121

SAN FRANCISCO OFFICE:

2450 Hanover, Palo Alto, California 94304
Telephone: AC415-326-5640 TWX: 910-373-1266

IN CANADA:

Digital Equipment of Canada, Ltd.,
150 Rosamund Street, Carleton Place, Ontario, Canada
Telephone: AC613-237-0772 TWX: 610-561-1650

IN EUROPE:

Digital Equipment GmbH, Theresienstrasse 29
Munich 2/West Germany
Telephone: 29 94 07, 29 25 66 Telex: 841-5-24226

Digital Equipment Corporation (UK) Ltd.
11 Castle Street

Reading, Berkshire, England
Telephone: Reading 57231 Telex: 851-84327

IN AUSTRALIA:

Digital Equipment Australia Pty. Ltd.,
89 Berry Street
North Sydney, New South Wales, Australia
Telephone: 92-0919 Telex: 790AA-20740
Cable: Digital, Sydney

DIGITAL SALES REPRESENTATIVES

IN THE SOUTHWEST:

DATRONICS INC.

7800 Westglen Drive, Houston, Texas 77042
Telephone: AC713-782-9851 TWX: 713-571-2154

DATRONICS INC.

Post Office Box 782, Kenner, Louisiana 70062
Telephone: AC504-721-1410

DATRONICS INC.

Post Office Box 13384, Fort Worth, Texas 76118
Telephone: AC817-281-1284 TWX: 817-281-3120

IN THE NORTHWEST:

SHOWALTER-JUDD, INC.

1806 South Bush Place, Seattle, Washington 98144
Telephone: 206-324-7911 TWX: 206-998-0323

IN JAPAN:

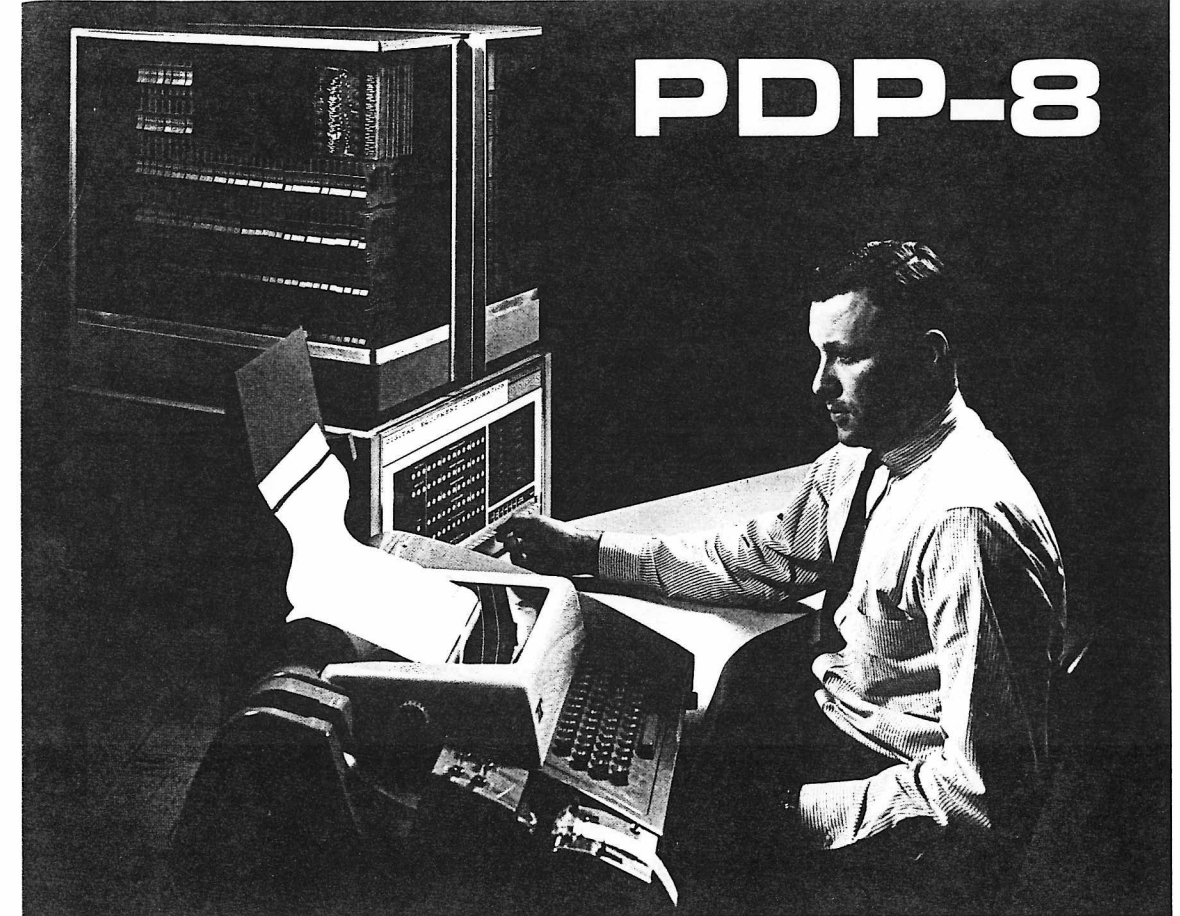
RIKEI TRADING CO.,

12, 2-Chome, Shiba Tamura-cho, Minato-ku,
Tokyo, Japan
Telephone: 591-5246 Cable Rikeigood, Tokyo

IN SWEDEN:

TELARE AB

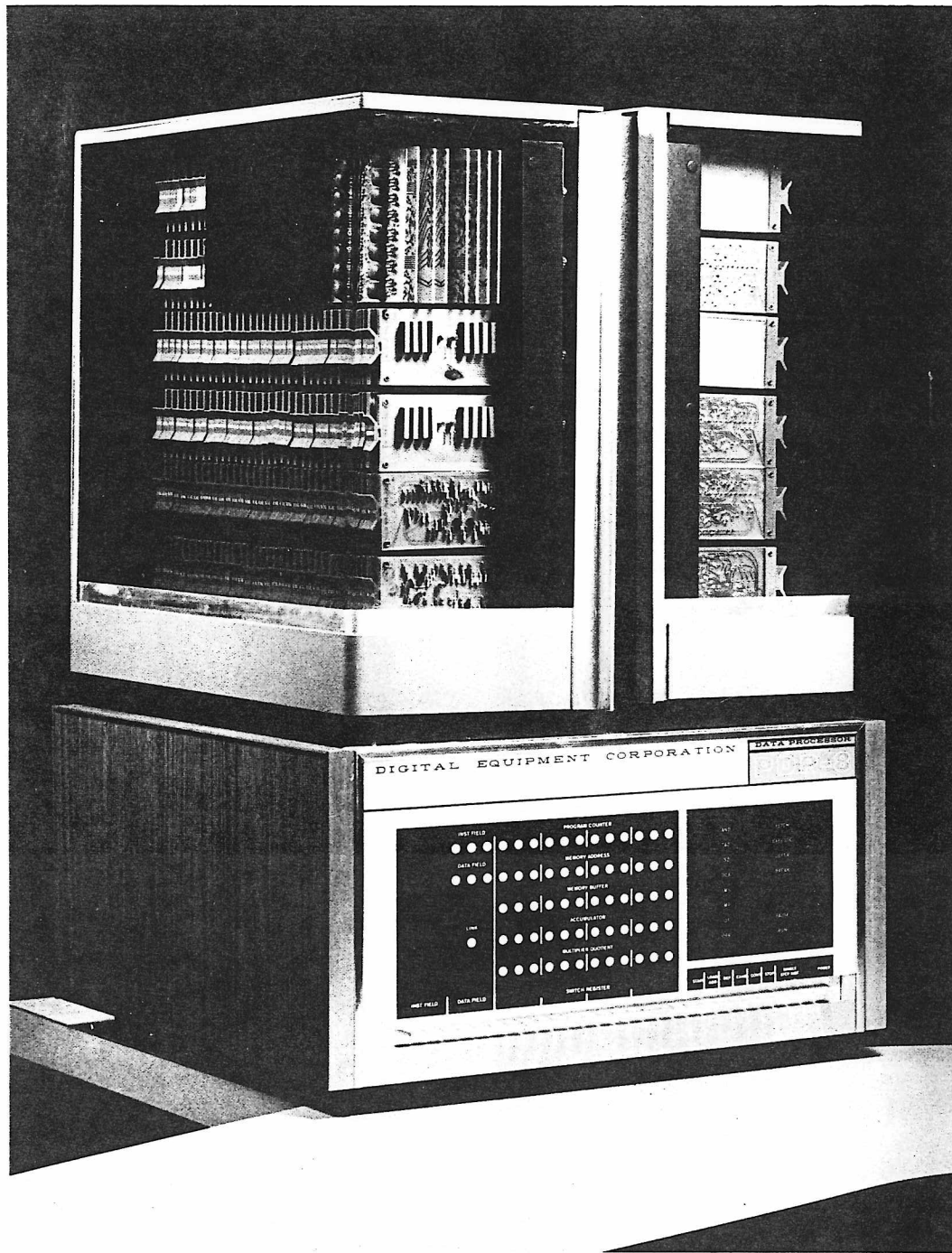
Industrigatan 4, Stockholm K, Sweden
Telephone: 54 33 24 Telex: 854-10178



PDP-8

A HIGH SPEED DIGITAL COMPUTER

DIGITAL



Copyright 1965 Digital Equipment Corporation

PDP-8

SCIENTIFIC COMPUTATION

SYSTEMS AND CONTROL APPLICATIONS

ON-LINE DATA COLLECTION AND REDUCTION

The programmed Data Processor-8 (PDP-8) makes available to engineering, scientific, and educational applications a compact but complete general-purpose digital computer with a high-speed, random-access, magnetic-core memory. It is intended for use in data processing or as a control element in on-line data handling, experiment monitoring, or a process control system. The standard PDP-8 is a complete hardware and software system, ready to perform general purpose computations and/or control operations on the day it is delivered. Optional data processing peripheral equipment or special control devices are easily connected to the PDP-8 to form a special-purpose system. Instruction format is simple and logical. One instruction format exists for each of four groups, so that format of individual instructions need not be memorized by the programmer. A complete software system accompanies each hardware system and contains FORTRAN, MACRO-8 assembler, a library of mathematical subroutines, and utility and maintenance programs.

The PDP-8 performs binary operations on 12- or 24-bit 2's complement numbers. PDP-8 circuits use DEC's integrated solid-state silicon FLIP CHIP[®] modules and incorporate provisions for marginal checking to insure reliability even under difficult operating conditions. Its 1.5-microsecond cycle time give it a computation rate of 333,333 additions per second and permit

it to handle programmed input/output data transfers of rates up to 2 million bits per second, or device-initiated input/output transfers at rates of up to 8 million bits per second.

The PDP-8 programming system includes a FORTRAN compiler which operates in a basic PDP-8 with 4096 words of core memory. Other elements of the programming system are the MACRO-8 Symbolic Assembler, Symbolic On-Line Debugging Program, Symbolic Tape Editor, Floating Point Package, mathematical function routines, and utility and maintenance programs. On-line tape editing and debugging, a unique DEC combination, establish a close programmer-machine operating mode in which the computer assists in program debugging and edits program tapes to incorporate the programmer's changes. The result is far more speed in preparing operating programs and getting them on-line.

The PDP-8 is capable of servicing up to 64 external devices each requiring up to three commands, or 96 devices each requiring two commands, or 192 devices each requiring one command. The external devices can be special-purpose units or any of DEC's wide selection of unique display or tape equipment and more conventional card, tape, and mass storage equipment. The addition of devices in the field requires no modification to the computer processor.

FEATURES

INTEGRATED ALL-SILICON PROCESSOR CIRCUITS
All logic circuits of the basic PDP-8 are constructed from DEC's popular new FLIP CHIP modules.

FULLY PARALLEL ARITHMETIC OPERATION
Reliable high-speed transfers of data, and arithmetic and logical operations within the computer are effected in parallel.

CONTINUOUS DISPLAY OF ACTIVE REGISTERS
The content of the accumulator, link, memory address register, program counter, memory buffer register, instruction register, and major state generator of the basic PDP-8 are continuously indicated by lamps on the operator console. The major registers of optional processor equipment such as the extended arithmetic element and the memory extension control are also indicated by lamps on the operator console with the addition of this equipment.

SINGLE STEP AND SINGLE INSTRUCTION MODES
Switches on the operator console allow a program to be advanced one instruction or one cycle at a time for classroom demonstration, program debugging, or maintenance purposes.

LINK BIT
To facilitate arithmetic operations a link bit is provided so that a carry from the accumulator can be program sampled.

MEMORY EXPANSION
The PDP-8 is a stored-program computer with a basic 4096-word core memory, capable of being expanded to 32,768 words in 4096-word increments.

INDIRECT ADDRESSING
Subroutine linkage and data accumulation is simplified by the ability to specify addresses indirectly.

AUTO-INDEXING
Eight core memory registers serve as auto-indexing registers to facilitate program searching, multiple input/output list processing, and sorting operations.

1.5 MICROSECOND CYCLE TIME
Instructions are executed in one or two cycles of 1.5 microsecond duration. Maximum execution time is 4.5 microseconds for instructions using indirect memory addressing.

MICRO-PROGRAMMABLE INSTRUCTIONS
All instructions which do not reference core memory (which do not contain a memory address) can be micro-programmed; which allows the programmer to specify several shift, skip, or input/output transfer commands to be performed within one instruction.

PROGRAM INTERRUPT
Standard facilities of the PDP-8 allow a peripheral device to interrupt the operating program and initiate a subroutine.

HIGH SPEED DATA BREAK
Facilities of the standard PDP-8 allow peripheral equipment to interrupt the operating program and effect data transfers to or from the computer core memory at a 1.5 microsecond per word transfer rate. Slower transfers are automatically interlaced with execution of instructions in the main program.

PRE-WIRED OPTIONS
Optional equipment which is closely related to the processor, such as the extended arithmetic element, memory extension control, and one of the analog-to-digital converter options, are pre-wired in the basic PDP-8 so that the time, effort, and cost involved in adding these options at the factory or in the field is a minimum.

FLEXIBLE MECHANICAL DESIGN
Several physical configurations of the computer are available so that it can be used alone in the table model configuration, can be installed as a portion of a user's system by installation in any standard 19-inch electronic equipment cabinet, or can be purchased in a standard DEC computer cabinet with other optional equipment (see Figures 1 and 2).

FIELD PROVEN SOFTWARE
Software supplied with the PDP-8 has been used in over 75 installations of the program-compatible PDP-5.

ONE-PASS FORTRAN SYMBOLIC COMPILER
A FORTRAN symbolic compiler which includes dynamic error correcting mode for tape modification without recompiling is supplied with each PDP-8.

MACRO-8 SYMBOLIC ASSEMBLER
Programs can be written in a convenient, meaningful symbolic language consisting of user-defined macro-instructions for translation into machine language by the MACRO-8 program.

DDT-8 PROGRAM
This program allows a programmer to correct and improve a new object program by communicating with the PDP-8 in the source language, via the Teletype unit.

SYMBOLIC TAPE EDITOR PROGRAM
Fast accurate checking, editing, and/or updating of a program can be accomplished with the aid of this program.

BUS I/O SYSTEM
Data, select code, and control signals which pass between the PDP-8 processor and peripheral equipment use bussed connections which simplify system cabling and permit system expansion without making changes to the processor.

BUFFERED INPUT/OUTPUT
All peripheral equipment contains an input/output buffer register for data to be transferred with the computer so that various devices can be operated simultaneously at their maximum speed. The processor does not wait for a device to complete its cycle before continuing the program.

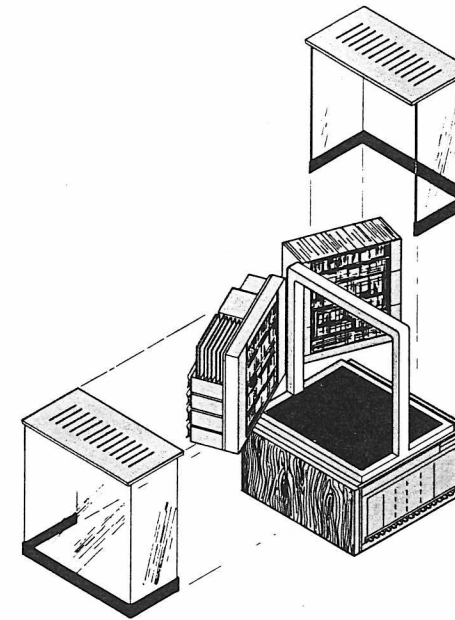


Figure 1 — Table Model PDP-8 showing removeable covers and swinging palets that allow access to all components.

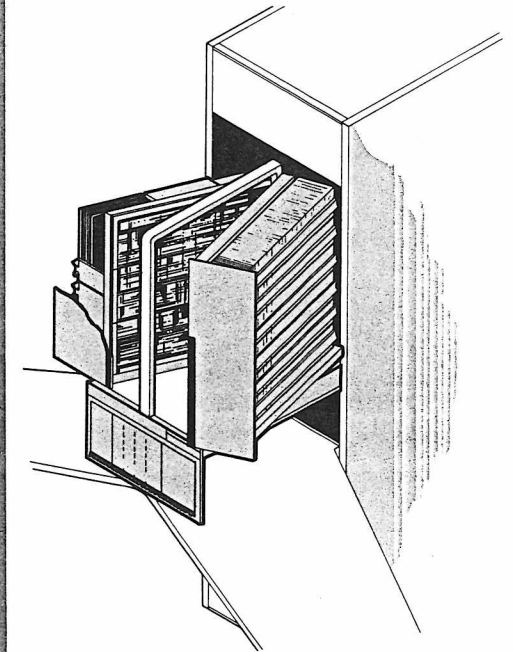


Figure 2 — Console Model PDP-8 showing sliding drawer that facilitates maintenance.

APPLICATIONS

PDP-8's are being used for applications such as:

RESEARCH EXPERIMENTS AND MEASUREMENT
Pulse-height analysis
Time-of-flight and bubble-chamber measurements
General physics investigation and multichannel-multi-parameter analyzer

QUALITY CONTROL TESTING AND STATISTICAL ANALYSIS
Tensile-strength testing
Electronic component testing
Analog and digital circuit module testing
Computer peripheral equipment testing

DATA ACQUISITION, LOGGING, REDUCTION, AND ANALYSIS
Oceanographic research
Biomedical research
Telemetry
Real-time analog signal monitoring

PROCESS CONTROL

Steel mill control
Typesetting
Chemical and Petroleum industry process control
Nuclear reactor monitor and control

DATA PROCESSING

Open shop computing
Hybrid processing
Media conversion

COMMUNICATIONS

Multi-user time-shared computing
Message switching systems
Data collection and processing from remote stations

EDUCATION AND TRAINING

The PDP-8 is an instruction-address, two's complement binary computer which is ideally suited for teaching engineering and programming fundamentals in colleges, high schools, military and industrial schools.

Specific information about each of these applications can be obtained by contacting our Maynard office.

STANDARD PDP-8 FUNCTIONAL COMPONENTS

The standard PDP-8, in any physical configuration, consists of a processor, core memory, operator console, input/output facilities, and a Teletype input/output device. This equipment, shown in Figure 3, constitutes a complete computer system capable of performing general purpose computations and/or control functions. Expansion of the system by addition of optional equipment can be accomplished to perform a specific function or to serve in a particular application.

PROCESSOR All logic and arithmetic operations, and control functions are performed by the processor. The major registers and control elements are as follows:

Accumulator (AC)

The AC performs the major programmed arithmetic and logic operations and serves as the data input/output register. The AC also serves as a digital buffer register for the optional Analog-to-Digital Converter Type 189.

Link (L)

This one-bit register serves as an extension of the AC. The content of this register can be program sampled and program modified. Overflow into the L from the AC can be checked by the program to greatly simplify and speed up single and multiple precision arithmetic routines.

Program Counter (PC)

The PC determines the core memory address from which the next instruction of a stored program is to be taken. The sequence in which instructions are performed is called program control, and is determined by the PC.

Memory Address Register (MA)

The location in core memory which is selected for data storage or retrieval is determined by the MA. This register can directly address all 4096 words of the standard core memory or in any pre-selected field of extended core memory.

Memory Buffer Register (MB)

The MB serves as a buffer register for all information passing between the processor and the core memory, and serves as a buffer directly between core memory and peripheral equipment during data break information transfers. The MB is also used as a distributor shift register for the Analog-to-Digital Converter Type 189.

Instruction Register (IR)

When an instruction word is read from core memory the three most significant bits (the operation code of all types of instructions) are loaded into the IR. The IR, then decodes the three-bit operation code and determines the basic functions to be performed by the computer, and determines the use to be made of the least significant nine bits of the instruction. When the operation code is decoded as octal number 0 through 5, a memory reference instruction is specified so the least significant bits of the instruction are interpreted to select a core memory address for the operation. When the operation code is decoded as 6 or 7, an augmented instruction is designated so the least significant bits of the instruction serve as an extension of the operation code and are decoded into numerous microinstructions.

Major State Generator

One or more major control states are entered to determine and execute an instruction. During any one instruction a state lasts for one computer cycle, or 1.5 microseconds. The major state generator determines the machine state during each cycle as a function of the current instruction, the current state, and the condition of the Break Request signal supplied to an input bus by peripheral equipment.

Switch Register (SR)

Twelve toggle switches on the operator console provide a means of manually establishing a word to be set into the computer. The content of the SR can be transferred into the PC as an address by pressing the LOAD ADDRESS key, or can be stored in core memory at the address contained in the PC by pressing the DEPOSIT key. The content of the SR can also be loaded into the AC under program control to allow program modification by programmed evaluation of the word manually set into the SR.

Output Bus Drivers

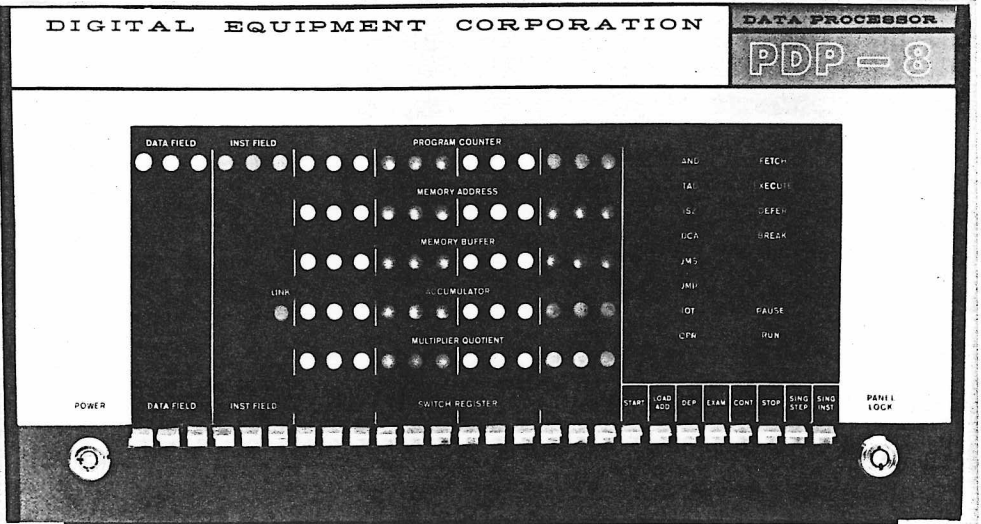
All major output signals from the standard PDP-8, used in programmed and data break information transfers, are power amplified by bus driver modules to allow them to drive a very heavy circuit load.

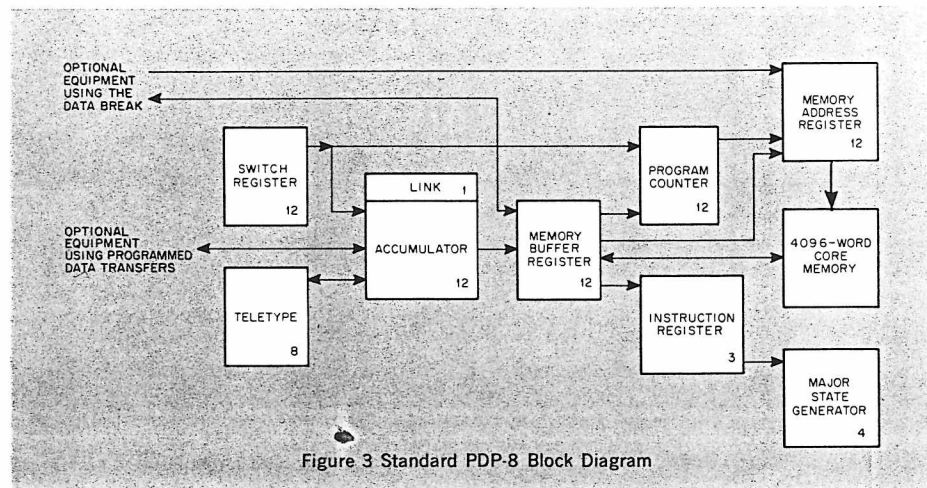
CORE MEMORY

Storage for instructions to be performed, or for data to be processed or distributed is provided by the core memory. Core memory for the standard PDP-8 has a capacity of 4096 words, 12 bits in length. The PDP-8 is the only computer in its price range with a full-size coincident-current random-address, ferrite-core memory.

OPERATOR CONSOLE

Keys, switches, indicators, and the switch register on the operator console allow manual address and data storage, core memory data examination, the normal start/stop/continue control, and single-step or single-instruction operation that allows each step or each instruction of the program to be monitored visually for demonstration or maintenance.





INPUT/OUTPUT FACILITIES

Standard equipment on the PDP-8 includes facilities for instruction skipping, program interrupt, programmed data transfers, and data break transfers.

Instruction Skip Facility

This facility allows the program to modify itself, or branch, as a function of the content of the AC, the content of the L, or the status of external equipment. Instructions are included in the repertoire of each optional device that allow the program to sense the condition of the device and then skip or proceed to the next instruction as a function of the device status. This feature can be considered programmed decision making.

Program Interrupt Facility

This facility allows signals from external equipment to interrupt the program and initiate a subroutine that services the equipment issuing the signal. Operation using this facility speeds the transfer of the data and control information between the computer and peripheral equipment by allowing conditions in the equipment to initiate a transfer of program control to a subroutine that enacts a transfer, rather than waiting for the main routine to sample the condition and initiate the subroutine.

Programmed Data Transfer Facility

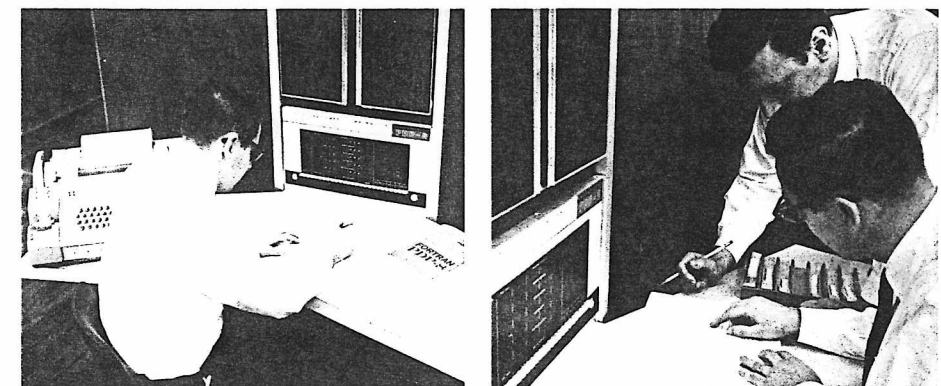
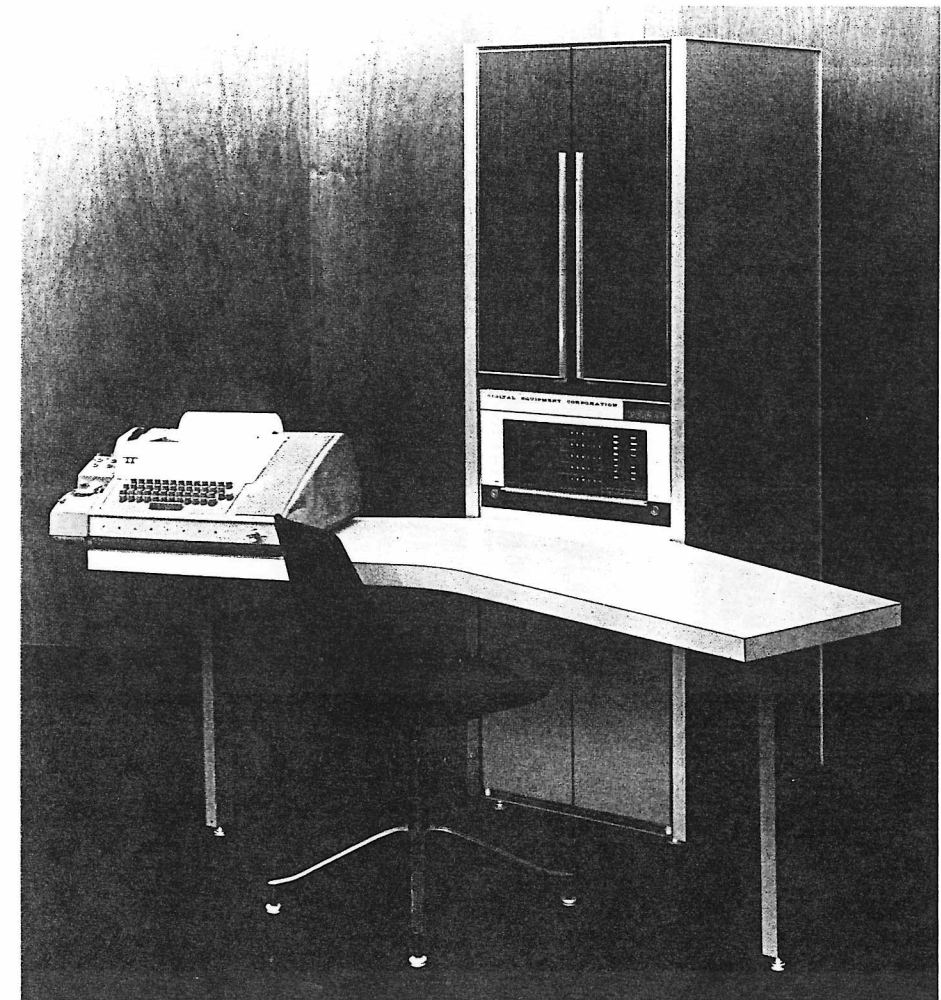
Normally data is transferred between the computer accumulator and an external device under program control. An input bus allows each device to clear the computer accumulator before transferring data into it.

Data Break Transfer Facility

Individual words or blocks of data can be transferred between a peripheral device and the computer core memory, via the MB, at a very rapid rate. A data break is entered upon receiving a Break Request signal and a Transfer Direction signal from the device. When the request is made the computer completes the current instruction, then enters the Break state to enact the transfers. Transfers are performed during every computer cycle until the Break Request signal is removed by the device. The core memory address of each transfer is specified by the peripheral device.

TELETYPE INPUT/OUTPUT DEVICE

A Teletype Model 33 Automatic Send Receive (ASR) set is included in each standard PDP-8. The ASR set transfers information into the PDP-8 from perforated tape or a keyboard, and supplies output information from the computer in the form of perforated tape and/or a typed message. The Teletype rate is 10 characters per second in either direction.



STANDARD PDP-8 INSTRUCTIONS

Instruction words are of two types: memory reference and augmented. Memory reference instructions store or retrieve data from core memory, while augmented instructions do not. All instructions utilize bits 0, 1, and 2 to specify the operation code. Operation codes of 0 through 5 specify memory reference instructions and codes of 6 and 7 specify augmented instructions.

MEMORY REFERENCE INSTRUCTIONS

Since the standard PDP-8 system contains a 4096-word core memory, 12 bits are required to address all locations. To simplify addressing, the core memory is divided into blocks, or pages, of 128 words (200₈ address). A memory reference instruction can directly address any one of 256 words; 128 words on page 0 or 128 words on the current page. All other core memory locations may be addressed indirectly. Word format of memory reference instructions is shown in Figure 4 and the instructions are listed in Table 1.

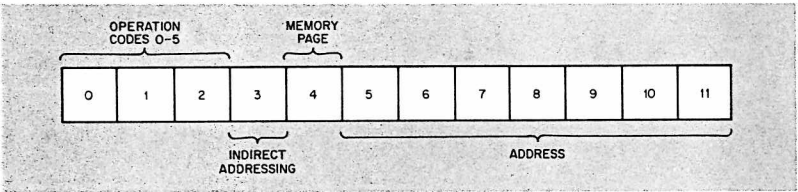


Figure 4 Memory Reference Instruction Format

TABLE 1 MEMORY REFERENCE INSTRUCTIONS

Mnemonic Symbol	Operation Code	Execution Time* (μsec)	Operation	Mnemonic Symbol	Operation Code	Execution Time* (μsec)	Operation
AND Y	0	3	Logical AND. The AND operation is performed between the content of memory location Y and the content of the AC. The result is left in the AC, the original content of the AC is lost, and the content of Y is unchanged. Corresponding bits of the AC and Y are operated upon independently. This instruction often called extract or mask can be considered as a bit-by-bit multiplication.	DCA Y	3	3	Deposit and clear AC. The content of the AC is deposited in core memory at address Y and the AC is cleared. The previous content of memory location Y is lost. This is the basic store instruction.
TAD Y	1	3	Two's complement add. The content of memory location Y is added to the content of the AC in two's complement arithmetic. The result of this addition is held in the AC, the original content of the AC is lost and the content of Y is unchanged. If there is a carry from AC0, the link is complemented. This link feature is very useful in multiple precision arithmetic.	JMS Y	4	3	Jump to subroutine. The content of the PC is deposited in core memory location Y and the next instruction is taken from core memory location Y + 1. This instruction is used for subroutine linkage.
ISZ Y	2	3	Increment and skip if zero. The content of memory location Y is incremented by one. If the resultant content of Y equals zero, the content of the PC is incremented by one and the next instruction is	JMP Y	5	1 1/2	Jump to Y. Address Y is set into the PC so that the next instruction is taken from core memory address Y. The original content of the PC is lost. This instruction is used to transfer program control to randomly selected core memory locations.

*The time listed is for direct addressing; add 1 1/2 microseconds to this time to determine indirect address execution time.

AUGMENTED INSTRUCTIONS

Instructions which do not reference core memory augment, or extend, the operation code by causing various operations to occur as a function of the content of bits 3 through 11. Augmented instructions with a basic operation code of 6 are input/

INPUT/OUTPUT TRANSFER INSTRUCTIONS

output transfer (IOT) instructions which serve peripheral equipment. Augmented instructions with a basic operation code of 7 are operate (OPR) instructions which deal with processing and sampling the information content of the AC and the L. Both of these instructions are microprogrammed, i.e., multiple operations can be specified and performed simultaneously according to the presence or absence of binary ones in bits 3 through 11.

Microinstructions of the IOT instruction addresses peripheral equipment to transfer information with it or to initiate operations within it. This instruction contains a 6-bit device selection code and three bits which can be programmed to produce pulses in the selected device that effect a transfer or initiate an operation. Figure 5 shows this instruction format. When an operation code of 6₈ is detected the pause/restart facility is used automatically to halt the program until the computer generates three command pulses at 1 microsecond intervals. These pulses are produced as a function of the content of bits 9, 10, and 11 of the instruction and are used to generate sequential command pulses in the selected device. Up to 64 individual devices can be selected to receive up to three command pulses, or up to 192 devices can each receive one command pulse. Use of the pause/restart facility allows IOT instructions to be performed in one computer cycle. The basic IOT microinstructions are listed in Table 2.

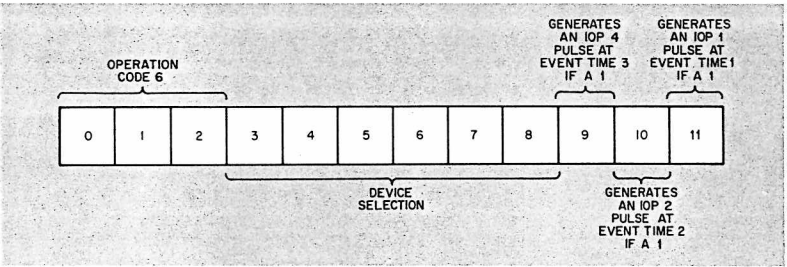


Figure 5 IOT Instruction Format

TABLE 2 BASIC IOT MICROINSTRUCTIONS

Mnemonic Symbol	Octal Code	Event Time	Operation	Mnemonic Symbol	Octal Code	Event Time	Operation
PROGRAM INTERRUPT							
ION	6001	1	Turn interrupt on and enable the computer to respond to an interrupt request. When this instruction is given, the computer executes the next instruction, then enables the interrupt. The additional instruction allows exit from the interrupt subroutine before allowing another interrupt to occur.	TLS	6046	2, 3	Load the TIO from the content of AC4-11, clear the teleprinter flag, and print and/or punch the character.
				MEMORY PARITY TYPE 188			
				SMP	6101	1	Skip if memory parity error flag = 0.
IOF	6002	2	Turn interrupt off i.e. disable the interrupt.	CMP	6102	2	Clear memory parity error flag.
				MEMORY EXTENSION CONTROL TYPE 183			
ADC	6004	3	Convert the analog input signal to a digital value.	CDF	62N1	1	Change data field N. The data field register is loaded with the selected field number (0 to 7). All subsequent memory requests for operands are automatically switched to that data field until the data field number is changed by a new CDF command.
TELETYPE KEYBOARD/READER							
KSF	6031	1	Skip if keyboard flag is a 1.				
KCC	6032	2	Clear AC and clear keyboard flag.	CIF	62N2	2	Prepare to change to instruction field N. The instruction field register is loaded with the selected field number (0 to 7). The next JMP or JMS instruction causes the new field to be entered.
KRS	6034	3	Read keyboard buffer static. (This is a static command in that neither the AC nor the keyboard flag is cleared.) The content of the TTI buffer is transferred into AC4-11.	RDF	6214	3	Read data field into AC 6-8. Bits 0-5 and 9-11 of the AC are not affected.
KRB	6036	2, 3	Clear AC, clear keyboard flag, and read the content of the keyboard buffer into the content of AC4-11.	RIF	6224	3	Same as RDF except reads the instruction field.
TELETYPE TELEPRINTER/PUNCH							
TSF	6041	1	Skip if teleprinter flag is a 1.	RIB	6234	3	Read interrupt buffer. The instruction field and data field stored during an interrupt are read into AC 6-8 and 9-11 respectively.
TCF	6042	2	Clear teleprinter flag.				
TPC	6044	3	Load the TIO from the content of AC4-11 and print and/or punch the character.	RMF	6244	3	Restore memory field. Used to exit from a program interrupt.

OPERATE INSTRUCTIONS

The OPR instruction consists of two basic groups of microinstructions. When bit 3 contains a binary zero, group OPR 1 is designated and the content of bits 4 through 11 is decoded to cause clear, complement, rotate, and increment operations. When bit 3 contains a binary one, group OPR 2 is designated and the content of bits 4 through 11 is decoded to cause operations that check the content of the AC and the L and continue to, or skip, the next instruction based on the results of the check. Any logical combination of bits within one group can be microprogrammed into one instruction. Figures 6 and 7 show the format of group 1 and group 2 operate microinstructions, and the basic OPR microinstructions are listed in Table 3.

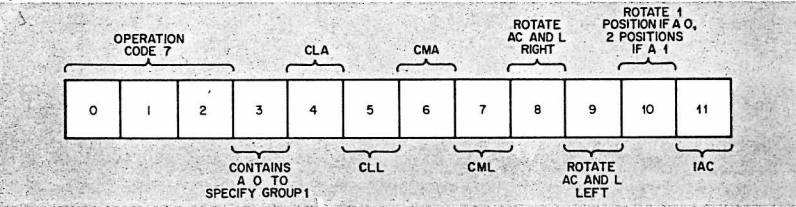


Figure 6 Group 1 Operate Microinstruction Format

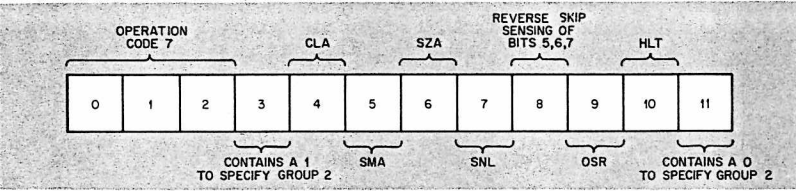


Figure 7 Group 2 Operate Microinstruction Format

TABLE 3 OPERATE MICROINSTRUCTIONS							
Mnemonic Symbol	Octal Code	Event Time	Operation	Mnemonic Symbol	Octal Code	Event Time	Operation
GROUP 1				GROUP 2			
NOP	7000	—	No operation. Causes a 1.6 μ sec program delay.	HLT	7402	1	Halt. Stops the program. If this instruction is combined with others in the OPR 2 group the computer stops immediately after completion of the cycle in process.
IAC	7001	2	Increment AC. The content of the AC is incremented by one in two's complement arithmetic.	OSR	7404	2	OR with switch register. The OR function is performed between the content of the SR and the content of the AC, with the result left in the AC.
RAL	7004	2	Rotate AC and L left. The content of the AC and the L are rotated left one place.	SKP	7410	1	Skip, unconditional. The next instruction is skipped.
RTL	7006	2	Rotate two places to the left. Equivalent to two successive RAL operations.	SNL	7420	1	Skip if L $\neq$ 0.
RAR	7010	2	Rotate AC and L right. The content of the AC and L are rotated right one place.	SZL	7430	1	Skip if L = 0.
RTR	7012	2	Rotate two places to the right. Equivalent to two successive RAR operations.	SZA	7440	1	Skip if AC = 0.
CML	7020	1	Complement L.	SNA	7450	1	Skip if AC $\neq$ 0.
CMA	7040	1	Complement AC. The content of the AC is set to the one's complement of its current content.	SZA SNL	7460	1	Skip if AC = 0, or L = 1, or both.
CIA	7041	1, 2	Complement and increment accumulator. Used to form two's complement.	SNA SZL	7470	1	Skip if AC $\neq$ 0 and L = 0.
CLL	7100	1	Clear L.	SMA	7500	1	Skip on minus AC. If the content of the AC is a negative number, the next instruction is skipped.
CLL RAL	7104	1, 2	Shift positive number one left.	SPA	7510	1	Skip on positive AC. If the content of the AC is a positive number, the next instruction is skipped.
CLL RTL	7106	1, 2	Clear link, rotate two left.	SMA SNL	7520	1	Skip if AC < 0, or L = 1, or both.
CLL RAR	7110	1, 2	Shift positive number one right.	SPA SZL	7530	1	Skip if AC $\geq$ 0 and if L = 0.
CLL RTR	7112	1, 2	Clear link, rotate two right.	SMA SZA	7540	1	Skip if AC $\leq$ 0.
STL	7120	1	Set link. The L is set to contain a binary 1.	SPA SNA	7550	1	Skip if AC > 0.
CLA	7200	1	Clear AC. To be used alone or in OPR 1 combinations.	CLA	7600	2	Clear AC. To be used alone or in OPR 2 combinations.
CLA IAC	7201	1, 2	Set AC = 1	LAS	7604	1	Load AC with SR.
GLK	7204	1, 2	Get link. Transfer L into AC11.	SZA CLA	7640	1	Skip if AC = 0, then clear AC.
CLA CLL	7300	1	Clear AC and L.	SNA CLA	7650	1	Skip if AC $\neq$ 0, then clear AC.
STA	7240	1	Set AC = -1. Each bit of the AC is set to contain a 1.	SMA CLA	7700	1	Skip if AC < 0, then clear AC.
				SPA CLA	7710	1	Skip if AC $\geq$ 0, then clear AC.

When the Extended Arithmetic Element Type 182 option is added to the PDP-8, a whole class of instructions is added to the OPR 2 instruction list. The extended arithmetic (EAE) microinstructions are specified by an operate instruction (operation code 7) in which bits 3 and 11 contain binary ones. Being augmented instructions, the EAE commands are microprogrammed and can be combined with each other to perform non-conflicting logical operations. Format and bit assignments of the EAE commands are indicated in Figure 8 and the commands are listed in Table 4.

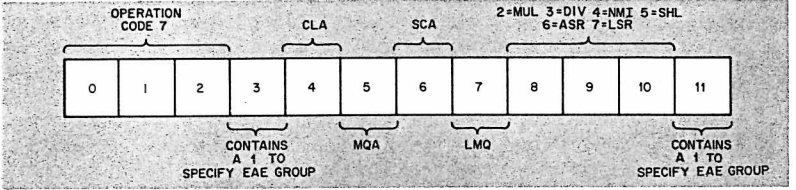
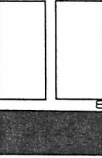


Figure 8 EAE Microinstruction Format

TABLE 4 EAE MICROINSTRUCTIONS							
Mnemonic Symbol	Octal Code	Event Time	Operation	Mnemonic Symbol	Octal Code	Event Time	Operation
MUL	7405	2	Multiply. The number held in the MQ is multiplied by the number held in the next successive core memory location after the MUL command. At the conclusion of this command the most significant 12 bits of the product are contained in the AC and the least significant 12 bits of the product are contained in the MQ.	LSR	7417	2	Logical shift right. The combined content of the AC and MQ is shifted left one position more than the number contained in the next successive core memory location following the LSR command. This command is similar to the ASR command except that zeros enter vacated positions instead of the sign bit entering these locations. Information shifted out of MQ11 is lost and the L is undisturbed during this operation.
DIV	7407	2	Divide. The 24-bit dividend held in the AC (most significant 12 bits) and the MQ (least significant 12 bits) is divided by the number held in the next successive core memory location following the DIV command. At the conclusion of this command the quotient is held in the MQ, the remainder is in the AC, and the L contains a 0. If the L contains a 1, divide overflow occurred so the operation was concluded after the first cycle of the division.	LMQ	7421	2	Load multiplier quotient. This command clears the MQ, loads the content of the AC into the MQ, then clears the AC.
NMI	7411	2	Normalize. This instruction is used as part of the conversion of a binary number to a fraction and an exponent for use in floating point arithmetic. The combined content of the AC and the MQ is shifted left by this one command until the content of ACO is not equal to the content of AC1, to form the fraction. Zeros are shifted into vacated MQ11 positions for each shift. At the conclusion of this operation, the step counter contains a number equal to the number of shifts performed. The content of L is lost.	SCA	7441	2	Step counter load into accumulator. The content of the step counter is transferred into the AC. The AC should be cleared prior to issuing this command or the CLA command can be combined with the SCA.
SHL	7413	2	Shift arithmetic left. This instruction shifts the combined content of the AC and MQ to the left one position more than the number of positions indicated by the content of the next successive core memory location following the SHL command. During the shifting, zeros are shifted into vacated MQ11 positions.	MQA	7501	2	Multiplier quotient load into accumulator. The content of the MQ is transferred into the AC. This command is given to load the 12 least significant bits of the product into the AC following a multiplication or to load the quotient into the AC following a division. The AC should be cleared prior to issuing this command or the CLA command can be combined with the MQA.
ASR	7415	2	Arithmetic shift right. The combined content of the AC and the MQ is shifted right one position	CLA	7601	1	Clear accumulator. The AC is cleared during event time 1, allowing this command to be combined with the other EAE commands that load the AC during event time 2 (such as SCA and MQA).



PROGRAMMING SYSTEM

The programming system for the PDP-8 consists of the MACRO-8 Symbolic Assembler, FORTRAN System compiler, Symbolic On-Line Debugging Program, Symbolic Tape Editor, Floating Point Package, mathematical function subroutines, and utility and maintenance programs. All operate with the basic computer. Because the PDP-8 makes high-speed computing available to many new users, the programming system was designed to simplify and accelerate the process of learning to program. At the same time, experienced programmers will find that it incorporates many advanced features. The system is intended to make immediately available to each user the full, general-purpose data processing capability of the PDP-8 and to serve as the operating nucleus for a growing library of programs and routines to be made available to all installations. New techniques, routines, and programs are constantly being developed, field-tested, and documented in the Digital Program Library for incorporation in users' systems.

MACRO-8 ASSEMBLER

The use of an assembly program has become standard practice in programming digital computers. This process allows the programmer to code his instructions in a symbolic language, one he can work with more conveniently than the 12-bit binary numbers which actually operate the computer. The assembly program then translates the symbolic language program into its machine code equivalent. The advantages are significant: the symbolic language is more meaningful and convenient to a programmer than a numeric code; instructions or data can be referred to by symbolic names without concern for, or even knowledge of, their actual addresses in core memory; decimal and alphabetical data can be expressed in a form more convenient than binary numbers; programs can be altered without extensive changes; and debugging is considerably simplified.

The MACRO-8 Symbolic Assembler accepts source programs written in the symbolic language and converts core memory locations, computer instructions, and operand addresses from the symbolic to the binary form. It produces an object program tape, a symbol table defining memory allocations, and useful diagnostic messages. Some of the outstanding features of this assembler are:

User-Defined MACROs: Groups of computer instructions required for the solution of specific operations or algorithms can be defined as a MACRO instruction by the user.

Double Precision Integer Pseudo Groups: Positive or negative double precision integers are allotted two consecutive core registers.

Double Precision Floating Point Constant: The format and rules for defining these constants is compatible with the format used by the PDP-8 Floating Point Package.

Operators: Symbols and integers may be combined with a number of operators

+	arithmetic plus	&	Boolean AND
-	arithmetic minus	!	Boolean inclusive OR

Literals: Symbolic or mnemonic literals (constants) are arranged automatically.

Variables: Variables can be assigned to page zero at any time and are assigned for the current page automatically.

Parameter Assignments: A symbol may be assigned the value of an expression.

Decimal and Octal Pseudo Operation Codes: The current radix may be specified by decimal or octal.

Text Facility: There are text facilities for single characters and blocks of text.

FORTRAN COMPILER

The FORTRAN (for FORMula TRANslation) System compiler for the PDP-8 lets the user express the problem he is trying to solve in a mixture of English words and mathematical statements that is close to the language of mathematics and is also intelligible to the computer. In addition to reducing the time needed for program preparation, the compiler enables users with little or no knowledge of the computer's organization and operating language to write effective programs for it. The FORTRAN Compiler contains the instructions the computer requires to perform the clerical work of translating the FORTRAN version of the problem statement into an object program in machine language. It also produces diagnostic messages. After compilation, the object program, the operating system and the data it will work with, are loaded into the computer for solution of the problem.

The FORTRAN language consists of four general types of statements: arithmetic, logic, control, and input/output. Fixed and floating point arithmetic can be expressed in both simple and complex numbers. FORTRAN functions include addition, subtraction, multiplication, division, sine, cosine, arctangent, square root, natural log, and exponential.

DEBUGGING PROGRAM

On-line debugging with DD-8 gives the user dynamic printed program status information. It gives him close control over program execution, preventing errors ("bugs") from destroying other portions of his program. He can monitor the execution of single instructions or subsections, change instructions or data in any format, and output a corrected program at the end of the debugging session.

Using the standard Teletype keyboard/reader and teleprinter/punch, the user can communicate conveniently with the PDP-8 in the symbols of his source language. He can control the execution of any portion of his object program by inserting breaks, or traps, in it. When the computer reaches a break, it transfers control of the object program to DDT. The user can then examine and modify the content of individual core memory registers to correct and improve his object program.

TAPE EDITOR

The Symbolic Tape Editor program is used to edit, correct, and update symbolic program tapes using the PDP-8 and the Teletype unit. With the editor in core memory, the user reads in portions of his symbolic tape, removes, changes, or adds instructions or operands, and gets back a complete new symbolic tape with errors removed. He can work through the program instruction by instruction, spot-check it, or concentrate on new sections.

FLOATING POINT

The Floating Point Package permits the PDP-8 to perform arithmetic operations that many other computers can perform only after the addition of costly optional hardware. Floating point operations automatically align the binary points of operands, retaining the maximum precision available by discarding leading zeros. In addition to increasing accuracy, floating point operations relieve the programmer of scaling problems common in fixed point operations. This is of particular advantage to the inexperienced programmer.

MATHEMATICAL FUNCTIONS

The programming system also includes a set of mathematical function routines to perform the following operations in both single and double precision: addition, subtraction, multiplication, division, square root, sine, cosine, arctangent, natural logarithm, and exponential.

UTILITY AND MAINTENANCE PROGRAMS

PDP-8 utility programs provide printouts or punchouts of core memory content in octal, decimal, or binary form, as specified by the user. Subroutines are provided for octal or decimal data transfer and binary-to-decimal, decimal-to-binary, and Teletype tape conversion.

A complete set of standard diagnostic programs is provided to simplify and expedite system maintenance. Program descriptions and manuals permit the user to effectively test the operation of the computer for proper core memory functioning and proper execution of instructions. In addition, diagnostic programs to check the performance of standard and optional peripheral devices are provided with the devices.

OPTIONAL EQUIPMENT

Equipment available for inclusion in a PDP-8 system includes options for the processor, reading and punching devices, plotting and printing output machinery, CRT displays, analog-to-digital conversion equipment, magnetic drum and tape storage devices, communication equipment, and equipment housing hardware.

PROCESSOR OPTIONS

EXTENDED ARITHMETIC ELEMENT TYPE 182

This option consists of circuits that allow the PDP-8 to perform parallel arithmetic operations on positive binary numbers much faster than by programmed subroutine. The option multiplies two 12-bit unsigned numbers to obtain a 24-bit product in an average of 15.2 μ sec (including access), divides a 24-bit dividend by a 12-bit divisor to obtain a 12-bit quotient in an average of 30.2 μ sec (including access), and normalizes a 12-bit number in 1.6 μ sec + 0.5 μ sec for each shift. When this element is added to the PDP-8 a whole group of microinstructions is added to the OPR instruction to permit automatic multiplication and division, and 24-bit shifting to normalize and scale arguments.

MEMORY EXTENSION CONTROL TYPE 183

The core memory address selection circuits are extended by this option to allow addition of up to seven fields of 4096 words, or up to a total of 32,768 words.

MEMORY MODULE TYPE 184

The basic PDP-8 core memory is extended by one field of 4096 words with the addition of each Type 184. From one to seven Memory Modules can be added to a PDP-8 containing a Memory Extension Control Type 183. The Type 184A is a 12-bit, 4096-word core array similar to standard core memory. The Type 184B is a 13-bit, 4096-word core array used to extend the memory of a system containing the Memory Parity Type 188.

MEMORY PARITY TYPE 188

Automatic checking of the transfer of each word between the processor and core memory is provided by this option. The Type 188 generates a 13th parity bit for each word written in core memory and checks parity during memory reading. A program interrupt is initiated upon detection of a parity error. With the addition of the Type 188 the standard 12-bit core memory and each field of extended memory (at additional cost), is replaced by a 13-bit core array to accommodate the parity bit.

POWER FAILURE OPTION TYPE KRO1

This option allows the contents of live registers to be

stored in core memory when power begins to fail and restarts the program when power returns.

DATA CHANNEL MULTIPLEXER TYPE 129

The Type 129 option expands the data break facilities of the computer to allow up to four input/output devices to transfer data directly with the core memory, via the memory buffer register. Simultaneous data break requests are serviced by the Type 129 according to a prewired priority.

READERS AND PUNCHES

HIGH SPEED PERFORATED TAPE READER AND CONTROL TYPE 750C

This equipment senses eight-channel, fan-fold, perforated Mylar or paper tape photoelectrically at 300 characters per second. A Perforated Tape Spooler Type 435 is available to facilitate use of rolled paper tape with the Type 750C in place of fan-fold tape.

HIGH SPEED PERFORATED TAPE PUNCH AND CONTROL TYPE 75E

This equipment punches eight-channel, fanfold paper tape at 63.3 lines per second. A Perforated Tape Spooler Type 436 option can be obtained to facilitate use of rolled paper tape with the Type 75E in place of fan-fold tape.

CARD READER AND CONTROL TYPE 451

Standard punched cards are read optically at up to 200 cards per minute on the Type 451A or up to 800 cards per minute on the Type 451B. Information punched on the cards is read column by column in binary or alphanumeric modes.

CARD PUNCH CONTROL TYPE 450

This device controls on-line buffered operation of a standard card punch machine. Cards are punched one row at a time at 40 millisecond intervals, providing a punching rate of 100 cards per minute. Any or all positions can be punched in any format.

PLOTTER AND PRINTER

INCREMENTAL PLOTTER CONTROL TYPE 350

One plotter selected from the following list of four models of California Computer Products Digital Incremental Recorder can be operated from a DEC

Increment Plotter Control Type 350. Characteristics of the four recorders are:

CCP Model	Step Size (inches)	Speed (steps/minute)	Paper Width (inches)
563	0.01	12,000	31
564	0.005	18,000	31
565	0.01	18,000	12
566	0.005	18,000	12

The Type 350 provides high-speed plotting of points, continuous curves, points connected by curves, curve identification symbols, letters, and numerals under program control.

AUTOMATIC LINE PRINTER TYPE 64

This machine prints a selection of 63 characters on a line of 120 characters at a rate of 300 lines per minute. Printing of one line of 120 characters can be carried out while the next 120 characters are being loaded into the printer. Loading, printing, and format are under program control. Format is program selected from a punched format tape in the printer.

CATHODE RAY TUBE DISPLAYS

OSCILLOSCOPE DISPLAY TYPE 34D

Computer data can be plotted at 100 kc, point by point, on a five inch oscilloscope, such as the Tektronic Model RM503, by this option. The horizontal axis of each point is determined by ten binary bits, and the vertical axis is determined by another ten binary bits. The Type 34D contains a three level brightness register. It can be obtained with or without the oscilloscope.

PRECISION CRT DISPLAY TYPE 30N

The Type 30N is a random-position point-plotting display with a self-contained, 16-inch CRT using magnetic deflection and focusing.

PHOTOMULTIPLIER LIGHT PEN TYPE 370

A fiber optic light pipe and photomultiplier in the light pen allow high-speed detection of information displayed on the Type 34D or 30N displays. Detection of information by the Type 370 can be sampled by the computer to alter the program.

ANALOG-TO-DIGITAL CONVERTERS

ANALOG-TO-DIGITAL CONVERTER TYPE 189

This successive approximation converter uses the AC and MB of the computer for its digital registers and so provides an inexpensive device capable of selected accuracy from 6 to 12 bits. This option is wired into the basic PDP-8 and requires modules to activate it. Analog input signal range is 0 to -10 volts.

GENERAL PURPOSE ANALOG-TO-DIGITAL CONVERTER TYPE 138E

The Type 138E is a high-speed, successive approxi-

mation converter with switch-selected word length from 6 to 12 bits and switch-selected error from $\pm 0.8\%$ to $\pm 0.025\%$. Conversion time varies from 9 to 35 microseconds according to these switch settings. Analog input signal range is 0 to -10 volts.

GENERAL PURPOSE MULTIPLEXER AND CONTROL TYPE 139E

Up to 64 analog input channels can be selected for application to the input of the Type 189 or Type 138E by the Type 139E. Channels can be program selected in sequence or by individual address. The number of channels that can be selected is determined by the number of optional Multiplexer Switches Type A100 used in the Type 139E. Each Type A100 can select two channels.

SERIAL MAGNETIC DRUM SYSTEM TYPE RM08

Blocks of 128 computer words are transferred between the computer core memory and Type RM08. Seven capacities are available from 8,192 to 262,144 words.

DETAPE TRANSPORT TYPE TU55 AND AUTOMATIC CONTROL TYPE 552

The DETape system provides a unique fixed-address magnetic tape facility for high-speed loading, read-out, and program updating. Up to eight transports can be used with one control.

MAGNETIC TAPE SYSTEM TYPE 580

The Type 580 is a semi-automatic system consisting of a magnetic tape control and one magnetic tape transport. Data transfer with this system is completely under program control and timing is controlled almost exclusively within this IBM-compatible system. Magnetic tape is read and written at 9,000 characters per second at a density of 200 bits per inch, or 25,000 cps at a density of 556 bpi.

AUTOMATIC MAGNETIC TAPE CONTROL TYPE 57A

Up to eight IBM or IBM-compatible tape transports can be used with the Type 57A to transfer information through the PDP-8 data break facility. Magnetic tape transports are controlled to read or write at densities of 200, 556, or 800 characters per inch at speeds of 75 or 112.5 inches per second.

MAGNETIC TAPE TRANSPORT TYPE 50

The Type 50 can be used with the Type 57A to read or write IBM-compatible magnetic tapes at transfer rates of 15,000 or 41,700 characters per second. Tape speed is 75 inches per second at densities of 200 or 556 characters per inch.

DIGITAL SALES AND SERVICE

MAIN OFFICE AND PLANT

146 Main Street, Maynard, Massachusetts 01754
Telephone: From Metropolitan Boston: 646-8600
Elsewhere: AC617-897-8821

TWX: 710-347-0212 Cable: Digital Mayn. Telex: 92-027

DIGITAL SALES OFFICES

NORTHEAST OFFICE:

146 Main Street, Maynard, Massachusetts 01754
Telephone: AC617-646-8600 TWX: 710-347-0212

BOSTON OFFICE:

111 Broadway, Cambridge, Massachusetts 02142
Telephone: AC617-491-6130 TWX: 710-320-0468

NEW YORK OFFICE:

1259 Route 46, Parsippany, New Jersey 07054
Telephone: AC201-335-3300 TWX: 510-235-8319

ROCHESTER OFFICE:

455 Empire Boulevard, Rochester, New York 14609
Telephone: AC716-482-2310 TWX: 510-253-3078

WASHINGTON OFFICE:

Executive Building
7100 Baltimore Ave., College Park, Maryland 20740
Telephone: AC301-779-1100 TWX: 710-826-9662

SOUTHEAST OFFICE:

Suite 91, Holiday Office Center
3322 Memorial Parkway, S.W., Huntsville, Ala. 35801
Telephone: AC205-881-7730 TWX: 510-579-2122

ORLANDO OFFICE:

Suite 20, 501 Park Avenue North
Winter Park, Florida 32789
Telephone: AC305-647-4511 TWX: 810-853-0254

PITTSBURGH OFFICE:

300 Seco Road, Monroeville, Pennsylvania 15146
Telephone: AC412-351-0700 TWX: 710-797-3657

CHICAGO OFFICE:

910 North Busse Highway, Park Ridge, Illinois 60068
Telephone: AC312-825-6626 TWX: 910-253-0342

DENVER OFFICE:

Suite 205
5200 South Quebec Way, Englewood, Colo. 80110
Telephone: AC303-771-1180 TWX: 910-931-2562

ANN ARBOR OFFICE:

3853 Research Park Drive, Ann Arbor, Mich. 48104
Telephone: AC313-761-1150 TWX: 810-223-6053

LOS ANGELES OFFICE:

8939 Sepulveda Boulevard, Los Angeles, Calif. 90045
Telephone: AC213-670-0690 TWX: 910-328-6121

SAN FRANCISCO OFFICE:

2450 Hanover, Palo Alto, California 94304
Telephone: AC415-326-5640 TWX: 910-373-1266

IN CANADA:

Digital Equipment of Canada, Ltd.,
150 Rosamond Street, Carleton Place, Ontario, Canada
Telephone: AC613-237-0772 Telex: 013-442

Digital Equipment of Canada, Ltd.,
39 Dundas Road East, Cooksville, Ontario, Canada
Telephone: AC416-279-1690 Telex: 022-9665

IN EUROPE:

Digital Equipment GmbH
8 Munich 2
Theresienstrasse 29, West Germany
Telephone: 29 94 07, 29 25 66 Telex: 841-5-24226

Digital Equipment GmbH

Aeussere Kanalstrasse 8
5 Cologne-Ehrenfeld, West Germany
Telephone: AC0221 518727

Digital Equipment Corporation (UK) Ltd.

11 Castle Street, Reading, Berkshire, England
Telephone: Reading 57231 Telex: 851-84327

Equipement Digital

65 Rue du Faubourg St. Honore, Paris 8°, France
Telephone: 256-1137, 256-1328 Telex: 84226705

IN AUSTRALIA:

Digital Equipment Australia Pty. Ltd.,
89 Berry Street
North Sydney, New South Wales, Australia
Telephone: 92-0919 Telex: 790AA-20740
Cable: Digital, Sydney

DIGITAL SALES REPRESENTATIVES

IN THE SOUTHWEST:

DATRONICS INC.

7800 Westglen Drive, Houston, Texas 77042
Telephone: AC713-782-9851 TWX: 713-571-2154

DATRONICS INC.

Post Office Box 782, Kenner, Louisiana 70062
Telephone: AC504-721-1410

DATRONICS INC.

Post Office Box 13384, Fort Worth, Texas 76118
Telephone: AC817-281-1284 TWX: 817-281-3120

IN THE NORTHWEST:

SHOWALTER-JUDD, INC.

1806 South Bush Place, Seattle, Washington 98144
Telephone: AC206-324-7911 TWX: 910-444-2212

IN JAPAN:

RIKEI TRADING CO., LTD.

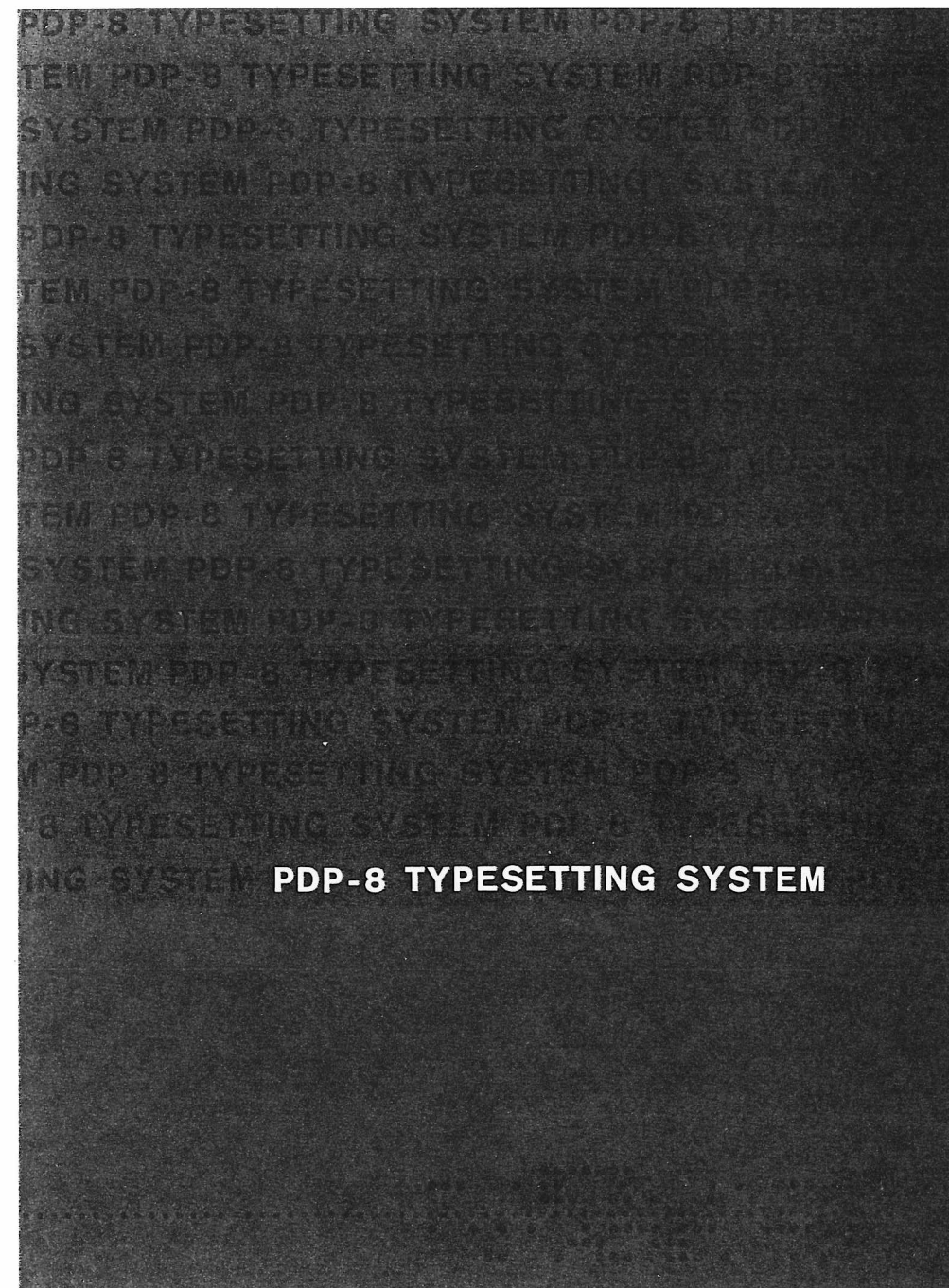
Kozato Kaikan Bldg.
No. 18-14, Nishishimbashi 1-chome
Minato-ku, Tokyo, Japan
Telephone: 591-5246 Telex: 781-TK4208 RIKEI

IN SWEDEN:

TELARE AB

Industrigatan 4, Stockholm K, Sweden
Telephone: 24-88-30 Telex: 854-10178

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS



DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

DIGITAL'S PDP-8 TYPESETTING SYSTEM IS BEING DELIVERED NOW — AND YOU CAN AFFORD IT NOW!

The PDP-Typesetting System justifies and hyphenates up to 12,000 lines of TTS tape per hour at better than 90% accuracy. That's fast enough to keep ten or more line casters busy.

Composition is more appealing with more even spacing than is possible with justifying perforators and the tightest lines possible without jamming the line casting machines.

The PDP-8 Typesetting System's 90% hyphenation accuracy can be increased at relatively low cost by adding more memory.

You get justification that's programmed for the tightest possible lines. This means that type is consistent throughout your publication. It also means that you save space, and eliminate over-tight lines that ruin matrices and cause expensive hang-ups.

You get a choice of 16 possible combinations of measure, type font and size. (Or more as an optional extra.)

You get far more output per keyboard operator. Experience shows that this increase should run about 100%. What's more, you can qualify keyboard operators with a week's training, instead of the 6 months or so it takes to train operators to justify and hyphenate with acceptable accuracy.

And you don't have to wait to put PDP-8 to work! Roll the PDP-8 Typesetting System into your composing room. Plug it in.

At \$24,900 you don't have to forgo electronic speed and economy in the composing room until other departments can share the cost of a computer.

Or split the computer's time among several departments in order to justify the price.

Or wait a year or so for delivery after you do decide to order.

PDP-8 can be working for you within 6 months. And earning its keep in the composing room alone from the minute it arrives.

LESS THAN 3 HOURS OF TYPING TIME SET THIS PAGE.

The PDP-8 Typesetting tape accepts idiot tape — which keyboard operators can punch out easily at 12 lines per minute — and turns it into hyphenated and justified TTS tape that operates your line-casting machines. Total typing time for two operators to set setting a page with 700 lines of text: about 30 minutes. Without the PDP-8 Typesetting System to perform time consuming hyphenation and justification, this page would require two perforators over an hour to set.



HEART OF THE PDP-8 TYPESETTING SYSTEM IS THE AMAZING PDP-8 COMPUTER

At $1\frac{1}{2}$ μ sec. cycle time, the Digital PDP-8 is one of the fastest computers in the world.

Its 4096 words of magnetic core memory give you all the rules you need for justification and regular hyphenation. Plus an exception dictionary of 200 words and a choice of up to 16 combinations of measure, type font and size.

PDP-8's reserve power and many input/output channels give you open-ended expandability. You can increase the core memory. Incorporate drum or low cost DEC tape memory. Attach more readers or punches. And step up the capability and capacity of your typesetting system as experience and growing workloads suggest.

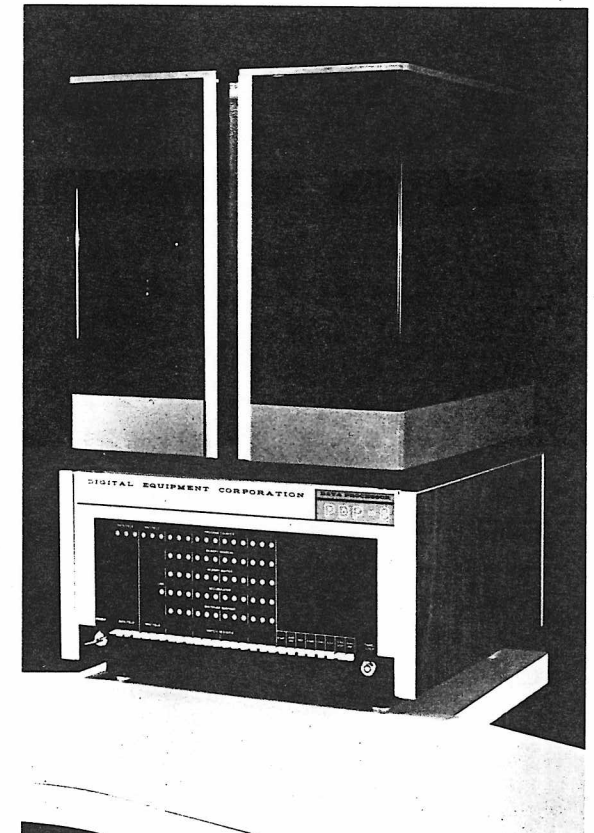
FAMOUS AS A GENERAL-PURPOSE COMPUTER

The PDP-8 enjoys a superb reputation wherever computers are used. The nation's outstanding research institutions have ordered over 175 to date.

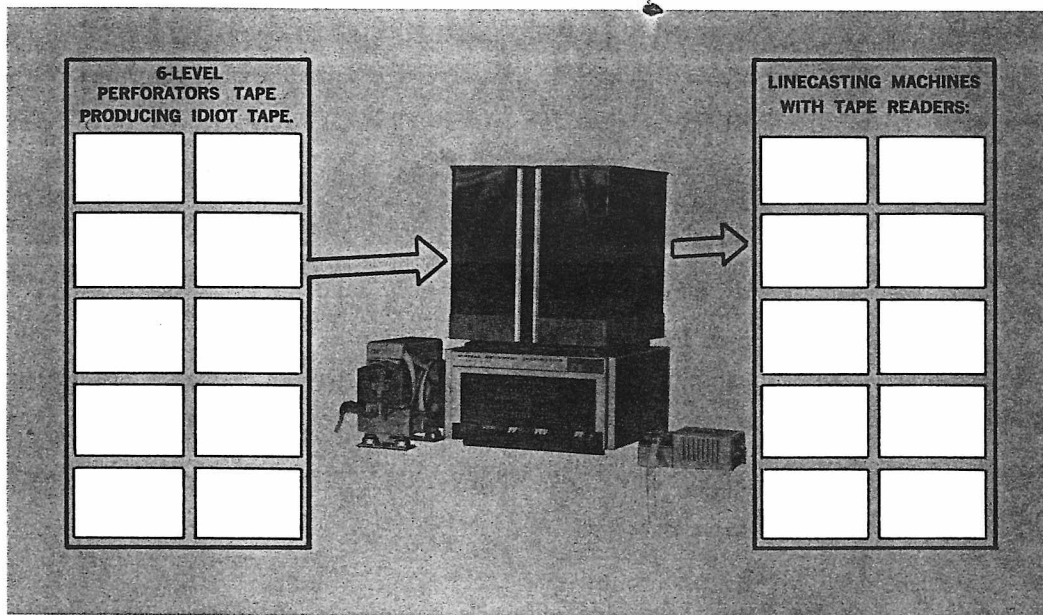
Yet withal, the PDP-8 is far and away the lowest priced computer of comparable quality.

What's the secret? Mainly this. Digital Equipment Corporation is the nation's No. 1 source of modules — the miniaturized electronic circuits that serve computers as gears and cogwheels serve a fine watch.

Digital's automated mass production facilities have drastically lowered both the cost of modules and of the computers we make with them.



HERE'S WHAT YOU GET WITH THE BASIC, \$24,900 PDP-8 SYSTEM



The PDP-8 Typesetting System accepts idiot tape as fast as 10 to 12 keyboard operators can produce it on Flexowriters or any other 6-level tape perforators. It turns the idiot tape into hyphenated/justified tape at a rate of 12,000 lines per hour — enough to keep 10 to 12 linecasting machines busy.

- PDP-8 computer. Makes all justification and hyphenation decisions automatically at electronic speeds.
- ASR 33 Teletype. Used for programming and

maintenance of computer.

- 110 cps Teletype CX reader: accepts idiot tape and feeds data into computer.
- 110 cps Teletype BRPE punch: punches out hyphenated/justified TTS tape.

CHANGEOVER IS PRACTICALLY PAINLESS

You install PDP-8 typesetting as easily and effortlessly as you would put in a new electric typewriter.

It need involve only two trifling changes.

1. Keyboard operators no longer have to justify or hyphenate.
2. Tape is handled twice instead of once.

Otherwise there is no need to revamp or retire your present procedures or equipment — in the composing room or anywhere else in your organization.

A SYSTEM THAT GROWS AS YOUR REQUIREMENTS GROW

With PDP-8 you buy what you require today — not two years or ten years from now.

As you gain experience with the system, you will realize what you do need and don't need for expansion or greater efficiency. And Digital will provide this — at costs in keeping with the economy of the basic system.

If you find, for instance, that you need additional CX tape readers, we can easily install them.

Or add more BRPE punches on the output side of the computer. And offer an allotting system that eliminates the tape handling problems of the torn tape system if that is what you want.

Or let the computer control up to 6 linecasters directly.

Or increase the possible combinations of line measure, type size and font to as many as 64.

THINKING PHOTO COMPOSITION?

You'll find that the PDP-8 system is ideal for the changeover to photo type.

It has the speed (uninhibited by other equipment, it can hit 500 lines per second); it has the program capability; and it offers high-speed magnetic tape that can call out any combination of measure, font or type size your photo composition equipment can deliver.

And Digital will help you utilize this versatility with PDP-8 programs that let you set type for display advertising, or even for magazines and books — pagination, captions, footnotes and all.

EASY TO OPERATE . . . EASY TO MAINTAIN

Normal touch typing skills are about all a keyboard operator needs for the PDP-8 system.

Format is established with the simplest of possible commands. Simply typing one number sets the measure, type size and font. This format will continue automatically until the operator calls for a new one.

Two or three keystrokes specify a change to lower magazine or upper magazine in linecasters with magazine mixing capability.

Operators can quad left, right or center with only two strokes. If automatic quadding is on the linecasting machine, the program will simply punch the appropriate code on the tape. Or if not, the program calculates the appropriate spaces and puts the space codes on the tape. If your present keyboards already have quad keys, they may be used to accomplish the same job.

Maintenance is equally simple and straightforward. Digital's excellent service department offers a variety of customer service contracts, and a one-week maintenance course for your own personnel.

DIGITAL SALES AND SERVICE

MAIN OFFICE AND PLANT

146 Main Street, Maynard, Massachusetts 01754
Telephone: From Metropolitan Boston: 646-8600
Elsewhere: AC617-897-8821
TWX: 710-347-0212 Cable: Digital Mayn. Telex: 092-027

DIGITAL SALES OFFICES

NORTHEAST OFFICE:

146 Main Street, Maynard, Massachusetts 01754
Telephone: AC617-646-8600 TWX: 710-347-0212

NEW YORK OFFICE:

1259 Route 46, Parsippany, New Jersey 07054
Telephone: AC201-335-0710 TWX: 510-235-8319

WASHINGTON OFFICE:

Executive Building
7100 Baltimore Ave., College Park, Maryland 20740
Telephone: AC301-779-1100 TWX: 710-826-9662

SOUTHEAST OFFICE:

Suite 91, Holiday Office Center
3322 Memorial Parkway, S.W., Huntsville, Ala. 35801
Telephone: AC205-881-7730 TWX: 510-579-2122

ORLANDO OFFICE:

1510 E. Colonial Drive, Orlando, Florida 32803
Telephone: AC305-422-4511 TWX: 810-850-0142

PITTSBURGH OFFICE:

300 Seco Road, Monroeville, Pennsylvania 15146
Telephone: AC412-351-0700 TWX: 710-797-3657

CHICAGO OFFICE:

910 North Busse Highway, Park Ridge, Illinois 60068
Telephone: AC312-825-6626 TWX: 312-823-3572

DENVER OFFICE:

Suite 205
5200 South Quebec Way, Englewood, Colo. 80110
Telephone: AC303-771-1180 TWX: 303-771-3549

ANN ARBOR OFFICE:

3853 Research Park Drive, Ann Arbor, Mich. 48104
Telephone: AC313-761-1150 TWX: 810-223-6053

LOS ANGELES OFFICE:

8939 Sepulveda Boulevard, Los Angeles, Calif. 90045
Telephone: AC213-670-0690 TWX: 910-328-6121

SAN FRANCISCO OFFICE:

2450 Hanover, Palo Alto, California 94304
Telephone: AC415-326-5640 TWX: 910-373-1266

IN CANADA:

Digital Equipment of Canada, Ltd.,
150 Rosamund Street, Carleton Place, Ontario, Canada
Telephone: AC613-237-0772 TWX: 610-561-1650

IN EUROPE:

Digital Equipment GmbH, Theresienstrasse 29
Munich 2/West Germany
Telephone: 29 94 07, 29 25 66 Telex: 841-5-24226

Digital Equipment Corporation (UK) Ltd.

11 Castle Street
Reading, Berkshire, England
Telephone: Reading 57231 Telex: 851-84327

Equipment Digital S.A.R.L.

65 Rue Du Faubourg St. Honore
Paris, France
Telephone: 256-1137, 256-1328

IN AUSTRALIA:

Digital Equipment Australia Pty. Ltd.,
89 Berry Street
North Sydney, New South Wales, Australia
Telephone: 92-0919 Telex: 790AA-20740
Cable: Digital, Sydney

DIGITAL SALES REPRESENTATIVES

IN THE SOUTHWEST:

DATRONICS INC.

7800 Westglen Drive, Houston, Texas 77042
Telephone: AC713-782-9851 TWX: 713-571-2154

DATRONICS INC.

Post Office Box 782, Kenner, Louisiana 70062
Telephone: AC504-721-1410

DATRONICS INC.

Post Office Box 13384, Fort Worth, Texas 76118
Telephone: AC817-281-1284 TWX: 817-281-3120

IN THE NORTHWEST:

SHOWALTER-JUDD, INC.

1806 South Bush Place, Seattle, Washington 98144
Telephone: 206-324-7911 TWX: 910-444-2212

IN JAPAN:

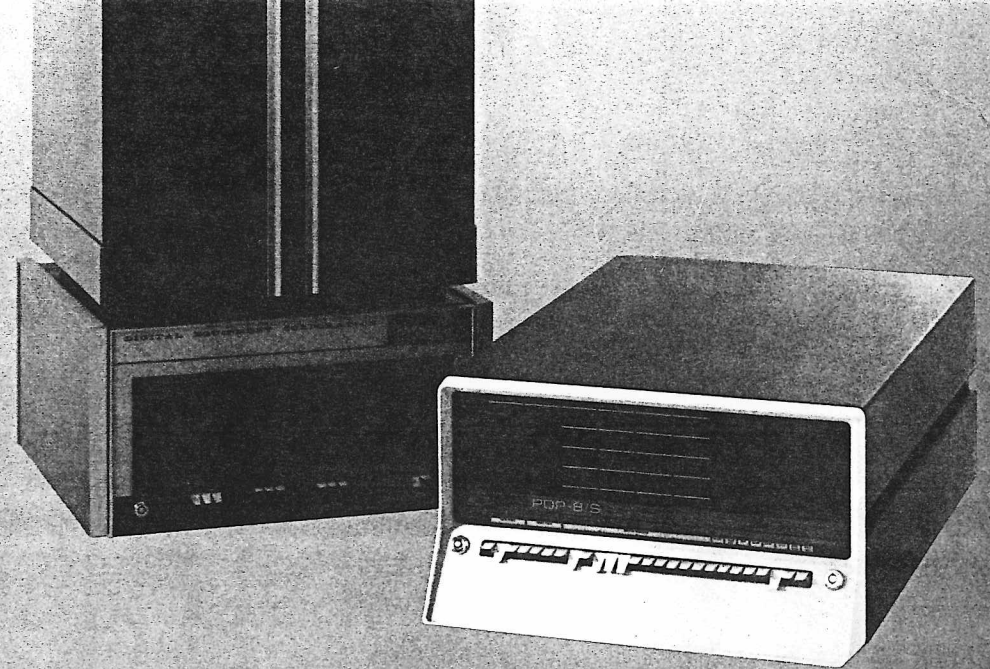
RIKEI TRADING CO.,

12, 2-Chome, Shiba Tamura-cho, Minato-ku,
Tokyo, Japan
Telephone: 591-5246 Cable Rikeigood, Tokyo
Telex: 781-TK-4208 RIKEI

IN SWEDEN:

TELARE AB

Industrigatan 4, Stockholm K, Sweden
Telephone: 54 33 24 Telex: 854-10178



AND NOW
THE \$10,000 COMPUTER...

digital

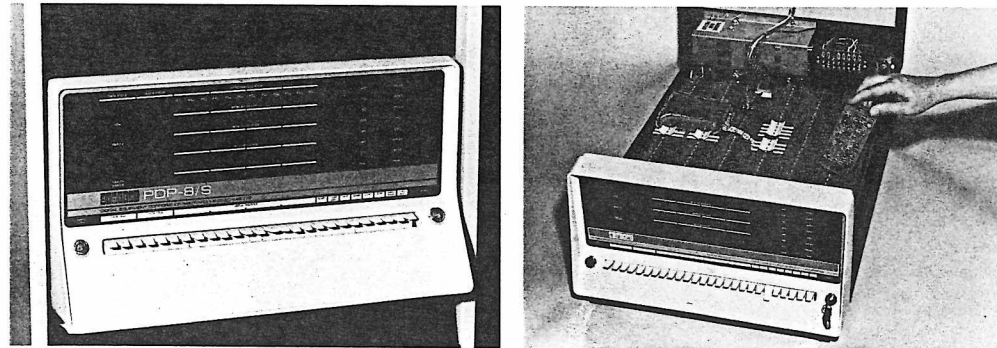
PDP-8/S

Available now, the PDP-8/S is a direct lineal descendent of the PDP-8, the most popular on-line, real time computer in science and engineering; over 500 PDP-8's are now in use around the world.

PDP-8 and PDP-8/S have 4096 word core memories (12 bit word). They have the same instruction set, the same flexibility I/O facilities, the same expansion capabilities, the same extensive set of standard options. Both use the same proven and constantly expanding software (including FORTRAN). However, the PDP-8 and PDP-8/S do not work at the same speed. The PDP-8 adds in 3.0 microseconds; the PDP-8/S takes 32 microseconds.

If that's fast enough for your application, the price is \$10,000. Full computer. Proven software. Teletype included.

Liberal O.E.M. discounts are available for multiple unit purchases. Modular construction permits rack mounting or repackaging. As the first under \$10,000 full computer, PDP-8/S opens up new economies for computer power in instruments and systems.



FEATURES

Digital Equipment Corporation's PDP-8/S, a small scale general-purpose computer is designed for use as an independent information handling facility in a larger computer system, or as a control element in a complex processing system. The PDP-8/S is a one-address, fixed word length, serial computer using a word length of 12-bits plus parity and two's complement arithmetic. Cycle time of the 4096-word random address magnetic core memory is 8 microseconds. Standard features of the system include indirect addressing and facilities for instruction skipping and program interruption as functions of input/output device conditions.

Addition is performed in 36 microseconds with one number in the accumulator. Subtraction is performed in 64 microseconds with the subtrahend in the accumulator. Multiplication is performed in approximately 5.35 milliseconds by a subroutine that operates on two signed 12-bit numbers that produce a 24-bit product, leaving the 12 most significant bits in the accumulator. Division of two signed 12-bit numbers is performed in approximately 7.38 milliseconds by a subroutine that produces a 12-bit remainder in core memory.

Flexible, high capacity, input/output capabilities of the computer operate a variety of peripheral equipment. In addition to standard teletype and perforated tape equipment, the system can operate in conjunction with all non-data break optional devices offered in the PDP-8 family line. Equipment of special design is easily adapted for connection into a PDP-8/S system. The computer is not modified with the addition of peripheral devices.

A single source of 115-volts, 60 cycle, single phase power operates the machine. An internal power supply produces all of the required operating voltages. Standard FLIP CHIP® Modules using hybrid silicon circuits insure reliable operation in ambient temperatures between 32 and 130 degrees Fahrenheit.

The PDP-8/S consists of a central processor, a memory unit, and input/output equipment and facilities. All arithmetic, logic, and system control operations of the standard PDP-8/S are performed by the processor. The central processor and memory are independent and asynchronous. The processor requests memory cycles only when required, each memory cycle consisting of a read followed by a write operation. Input and output addresses and data buffering for the core memory are performed by registers of the processor, and operation of the memory is under control of its own timing logic.

Interface circuits for the processor allow bussed connections to a variety of peripheral equipment. Each input/output device is responsible for detecting its own selection code and for providing any necessary input gating. Individually programmed data transfers between the processor and peripheral equipment take place through the processor accumulator. Standard features of the PDP-8/S also allow peripheral equipment to perform certain control functions such as instruction skipping, and a transfer of program control when initiated by a program interrupt.

Standard peripheral equipment provided with each PDP-8/S system consists of a Teletype Model 33 Automatic Send/Receive set and a Teletype control. The Teletype unit is a standard machine operating from serial 11 unit code characters at a rate of 10 characters per second. The teletype provides a means of supplying data to the computer from perforated tape or by the key board, and supplies data as an output from the computer in the form of perforated tapes or typed copy. The Teletype control serves as a serial-to-parallel converter for Teletype inputs to the computer, and serves as a parallel-to-serial converter for computer output signals to the Teletype unit. The Teletype control functions are performed by two functional modules which are built from *monolithic* integrated circuits and mounted on two standard double size FLIP CHIP® cards.

digital
SALES AND SERVICE
MAIN OFFICE AND PLANT

146 Main Street, Maynard, Massachusetts 01754
Telephone: From Metropolitan Boston: 646-8600
Elsewhere: AC617-897-8821
TWX: 710-347-0212 Cable: Digital Mayn. Telex: 920456

DOMESTIC

NORTHEASTERN

NORTHEAST OFFICE:
146 Main Street, Maynard, Massachusetts 01754
Telephone: AC617-646-8600 TWX: 710-347-0212

BOSTON OFFICE:
899 Main Street, Cambridge, Massachusetts 02142
Telephone: AC617-491-6130 TWX: 710-320-0468

ROCHESTER OFFICE:
455 Empire Boulevard, Rochester, New York 14609
Telephone: AC716-482-2310 TWX: 510-253-3078

CONNECTICUT OFFICE:
129 College Street, New Haven, Connecticut

MID-ATLANTIC
NEW YORK OFFICE:
1259 Route 46, Parsippany, New Jersey 07054
Telephone: AC201-335-3300 AC212-279-4735
TWX: 510-235-8319

PHILADELPHIA OFFICE:
Southampton Medical & Professional Bldg.
Second Street Pike, Southampton, Pa. 18966
Telephone: AC215-357-9450 (9451) TWX: 510-667-1724

WASHINGTON OFFICE:
Executive Building
7100 Baltimore Ave., College Park, Maryland 20740
Telephone: AC301-779-1100 TWX: 710-826-9662

SOUTHERN

HUNTSVILLE OFFICE:
Suite 41 — Holiday Office Center
3322 Memorial Parkway S.W., Huntsville, Ala. 35801
Telephone: AC205-881-7730 TWX: 510-579-2122

CANADA

Digital Equipment of Canada, Ltd.
150 Rosamond Street, Carleton Place, Ontario, Canada
Telephone: AC613-257-2615 Telex: 013-442

Digital Equipment of Canada, Ltd.
39 Dundas Road East, Cooksville, Ontario, Canada
Telephone: AC416-279-1690 Telex: 022-9665

GERMANY

Digital Equipment GmbH
Theresienstrasse 29
8 München 2, West Germany
Telephone: 29 94 007, 29 25 66 Telex: 841-5-24226

Digital Equipment GmbH
5 Koeln-Ehrenfeld
Neue Weyerstr. 10
West Germany

Telephone: AC0221-235-501
Telex: 888-2269
Telegram: Flip Chip Koeln

ENGLAND

Digital Equipment Corp. (U.K.) Ltd.
3 Arkwright Road, Reading, Berkshire, England
Telephone: Reading 57231 Telex: 851-84327

HOUSTON OFFICE:

3417 Milam Street, Suite A, Houston, Texas 77002
Telephone: AC713-523-2529 TWX: 910-881-1651

MIDWEST

PITTSBURGH OFFICE:
300 Seco Road, Monroeville, Pennsylvania 15146
Telephone: AC412-351-0700 TWX: 710-797-3657

CHICAGO OFFICE:
910 North Busse Highway, Park Ridge, Illinois 60068
Telephone: AC312-825-6625 TWX: 910-253-0342

ANN ARBOR OFFICE:
3853 Research Park Drive, Ann Arbor, Michigan 48104
Telephone: AC313-761-1150 TWX: 810-223-6053

WESTERN

LOS ANGELES OFFICE:
801 E. Ball Road, Anaheim, California 92805
Telephone: AC714-776-6932 or AC213-625-7669
TWX: 910-591-1189

SAN FRANCISCO OFFICE:
2450 Hanover Street, Palo Alto, California 94304
Telephone: AC415-326-5640 TWX: 910-373-1266

SEATTLE OFFICE:
McAusland Building, 10210 N.E. 8th Street
Bellevue, Washington 98004
Telephone: AC206-454-4058 TWX: 910-443-2306

DENVER OFFICE:
Suite 205 —
5200 South Quebec Way, Englewood, Col. 80110
Telephone: AC303-771-1180 TWX: 910-931-2562

INTERNATIONAL

Digital Equipment Corporation (UK) Ltd.
The Precinct
46 Bolton Road, Walkden, Manchester, England
Telephone: Walkden 5660

FRANCE

Equipment Digital
65 Rue du Faubourg St. Honore, Paris 8*, France
Telephone: 256-1137, 256-1328 Telex: 842-26705

AUSTRALIA

Digital Equipment Australia Pty. Ltd.
89 Berry Street
North Sydney, New South Wales, Australia
Telephone: 92-0919 Telex: 790AA-20740
Cable: Digital, Sydney

Digital Equipment Australia Pty. Ltd.
36 Outram Street
West Perth, Western Australia
Telephone: 214-993

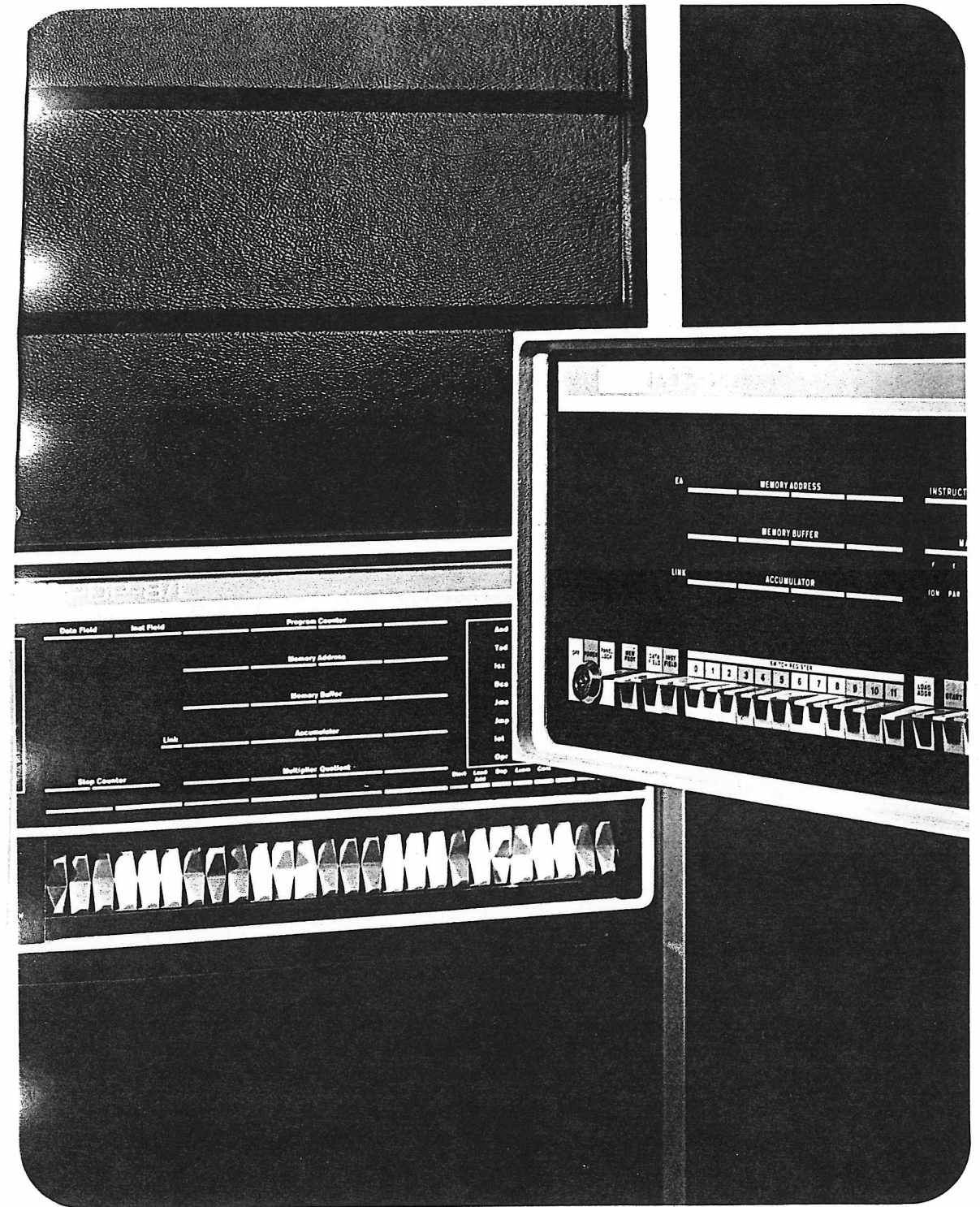
JAPAN

Rikei Trading Co., Ltd.
Kozato Kaikan Bldg.
No. 18-14, Nishishimbashi 1-chome
Minato-ku, Tokyo, Japan
Telephone: 5915246 Telex: 7814208

SWEDEN

Telare AB
Box #49025, Stockholm 49, Sweden
Telephone: 24-88-30 Telex: 854-10178

DIGITAL EQUIPMENT CORPORATION PDP-8/I and PDP-8/L



DOMESTIC

NORTHEASTERN

NORTHEAST OFFICE:
146 Main Street, Maynard, Massachusetts 01754
Telephone: AC617-646-8600 TWX: 710-347-0212

BOSTON OFFICE:

899 Main Street, Cambridge, Massachusetts 02142
Telephone: AC617-491-6130 TWX: 710-320-0468

ROCHESTER OFFICE:

455 Empire Boulevard, Rochester, New York 14609
Telephone: AC716-482-2310 TWX: 510-253-3078

CONNECTICUT OFFICE:

129 College Street, New Haven, Connecticut

MID-ATLANTIC

NEW YORK OFFICE:

1259 Route 46, Parsippany, New Jersey 07054
Telephone: AC201-335-3300 AC212-279-4735
TWX: 510-235-8319

PHILADELPHIA OFFICE:

Southampton Medical & Professional Bldg.
Second Street Pike, Southampton, Pa. 18966
Telephone: AC215-357-9450 (9451) TWX: 510-667-1724

WASHINGTON OFFICE:

Executive Building
7100 Baltimore Ave., College Park, Maryland 20740

HOUSTON OFFICE:

3417 Milam Street, Suite A, Houston, Texas 77002
Telephone: AC713-523-2529 TWX: 910-881-1651

MIDWEST

PITTSBURGH OFFICE:

300 Seco Road, Monroeville, Pennsylvania 15146
Telephone: AC412-351-0700 TWX: 710-797-3657

CHICAGO OFFICE:

910 North Busse Highway, Park Ridge, Illinois 60068
Telephone: AC312-825-6625 TWX: 910-253-0342

ANN ARBOR OFFICE:

3853 Research Park Drive, Ann Arbor, Michigan 48104
Telephone: AC313-761-1150 TWX: 810-223-6053

WESTERN

LOS ANGELES OFFICE:

801 E. Ball Road, Anaheim, California 92805
Telephone: AC714-776-6932 or AC213-625-7669
TWX: 910-591-1189

SAN FRANCISCO OFFICE:

2450 Hanover Street, Palo Alto, California 94304
Telephone: AC415-326-5640 TWX: 910-373-1266

SEATTLE OFFICE:

McAusland Building, 10210 N.E. 8th Street
Bellevue, Washington 98004

PDP-10 HARDWARE CHARACTERISTICS

GENERAL

General purpose, stored program, binary digital computer
Parallel processing
Asynchronous operation
36 bit word
16 general purpose registers
High speed multiplexor channels
Programmed-priority interrupt system
7 fully-nested interrupt levels
Flexible I/O bus structure
Easily interfaced to special devices
Executive and user modes of operation
Functional operator console

PROCESSOR

16 accumulators
15 index registers
Multilevel indirect addressing
Floating point hardware to 8 decimal digits
Immediate mode addressing of operands
64 programmed operators
Highly symmetric, logically complete order code
365 powerful instructions
Easy to learn, modular mnemonics
Data Manipulation by:
36 bit word, half word, double word
Bytes of any size
Memory blocks of any size

Typical Arithmetic Instruction times:

Fixed point 36 bit add — 2.53 μ s
Fixed point 72 bit multiply — 10.60 μ s
Floating point add — 6.57 μ s
Floating point multiply — 10.45 μ s
Jump — 1.36 μ s
16 Boolean operations
8 arithmetic comparison instructions
16 bit test/modify instructions
Push Down Stack Operations for:
Data manipulation
Inter-program transfer
Re-entrant code

STORAGE

262,144 directly addressable 36 bit words
1.0 microsecond memory cycle time
Asynchronous operation with respect to processors
.55 μ s read Access time
Automatic parity checking
Memory protection
Dynamic program relocation
Memory Bus Structure permitting:
Multiprocessing
Memory modules of different speeds
Program/data overlap
Interleaving on low order bit(s)

PRINTED IN U.S.A.

50-1/68

FRAP AND DECAL

DEC PROGRAMMED DATA PROCESSOR

DIGITAL EQUIPMENT CORPORATION • MAYNARD • MASSACHUSETTS